14 | Construction

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Constructional activity combines perception with motor response and inevitably has a spatial component. The integral role of visuoperception in constructional activity becomes evident when persons with more than very mild perceptual deficits encounter difficulty on constructional tasks. Yet some impaired constructional performances occur without any concomitant impairment of visuoperceptual functions. Commonly used constructional tests vary considerably in their level of difficulty and in the demands that they place on other cognitive functions. Because of the complexity of functions that influence performance on a constructional test, numerical scores convey only a limited amount of information about an individual's performance. Careful observation of how patients go about doing constructional tasks and the types of errors they make is necessary to distinguish the possible contributions of perceptual deficits, spatial confusion, attentional impairments, organizational limitations, motor planning difficulties, and motivational problems: the more complex the constructional test, the less likely it is that a specific deficit can be identified.

The concept of constructional functions embraces two large classes of activities—drawing, and building or assembling. The tendency for drawing and assembling impairments to occur together—though significant—is so variable that these two types of activity need to be evaluated separately. There is ample evidence that impaired performance on constructional tests predicts limitations in important activities such as meal planning (Neistadt, 1993) and driving (Gallo et al., 1999; K. Johansson et al., 1996; Marottoli et al., 1994), yet the assessment of visuospatial abilities in clinical practice is often rather cursory. This is in no small part related to the fact that visuospatial functions—and constructional abilities in particular—lack the rich conceptual framework surrounding language abilities. Guérin, Ska, and Belleville (1999) detailed a cognitive neuropsychological model for drawing, but the applicability of this type of model to clinical practice remains to be established.

Awareness that the two cerebral hemispheres differ in their information processing capacities has brought increasing attention to the differences in how patients with unilateral lesions perform constructional tasks. A number of characteristic constructional tendencies of these patients have been described (Benton, 1967 [1985]; J.L. Mack and Levine, 1981; Walsh and Darby, 1999; McCarthy and Warrington, 1990). Patients with right hemisphere dysfunction tend to take a piecemeal, fragmented approach, losing the overall "gestalt" of the constructional task. Although some patients with right hemisphere damage produce very sparse, sketchy drawings, others create highly elaborated pictures that do not "hang together," i.e., drawings that may lack important components (e.g., the pedals on a bike), or that contain serious distortions in perspective or proportions yet simultaneously have a repetitive overdetailing that gives the drawing a not unpleasant, rhythmical quality (see Fig. 6.2, p. 141, for an example). They may even not attend to the left side of a construction or—occasionally—pile up items (e.g., lines in a drawing, blocks, or puzzle pieces) on the left.

When asked to copy a large-scale stimulus—in the shape of a letter, for example—that is made up of many smaller stimuli of a different shape (e.g., global–local stimuli such as those depicted in Fig. 3.8, p. 55), patients with right-sided lesions will typically focus on reproducing the small stimuli without appreciating the larger configuration that they form (Delis, Kiefner, and Fridlund, 1988). Patients with right hemisphere lesions often proceed from right to left on drawing or assembly tests (E. Kaplan, Fein, et al., 1991; Milberg, Hebben, and Kaplan, 1996), in contrast to the more common approach of working from left to right. This is not an infallible indicator of right hemisphere dysfunction, however, because left-handed persons and those whose language is read from right to left often draw figures from right to left as well (Vaid et al., 2002).

In contrast, patients with left-sided lesions may get the overall idea and proportions of the construction correct and their drawings may be symmetric, but they tend to omit details and generally turn out a shabby production. Unlike patients with right hemisphere dysfunction, those with lesions on the left may do better when presented with a model as opposed to drawing to command (Hécaen and Assal, 1970) and their performance will often improve with repetition (Warrington, James, and Kinsbourne, 1966). On a global–local task, these patients will tend to ignore the smaller internal stimuli and focus instead on the larger shape (Delis, Kiefner, and Fridlund, 1988). Thus the frequency of errors does not seem to differentiate patients with left and right hemisphere lesions so much as qualitative features of these errors (Gainotti and Tiacci, 1970; Hécaen and Assal, 1970; McCarthy and Warrington, 1990).

The site of the lesion along the anterior–posterior axis also affects the expression of constructional impairment (F.W. Black and Bernard, 1984; A. Smith, 1980; Walsh and Darby, 1999). While patients with right posterior lesions will, in general, be most likely to have impaired constructional functions, many fewer right hemisphere damaged patients who have anterior lesions display constructional deficits. Drawings made by patients with lateralized subcortical lesions display the same error patterns as those of cortically lesioned patients, but subcortical patients tend to have more widespread deficits (A. Kirk and Kertesz, 1993).

DRAWING

The major subdivisions within this class are copying and free drawing. The overlap between them is considerable, yet many persons whose drawing skills are impaired can copy with reasonable accuracy (Libon, Malamut, et al., 1996; Rouleau et al., 1996). Reverse instances are relatively rare (Messerli et al., 1979). This differential becomes pronounced with advancing age, as copying is relatively unaffected—particularly copying of simple or familiar material—but free drawing shows a disproportionately greater loss of details and organizational quality with aging (Ska, Desilets, and Nespoulous, 1986). Studies of children have shown that drawing ability develops in a predictable sequence—from simple closed geometric shapes, to open (three-dimensional) shapes, to segmented human figures, and finally to complete human figures (Barrett and Eames, 1996). This developmental sequence is useful to keep in mind in evaluating the drawing abilities of patients who may be able to draw simple geometric figures quite competently but then struggle to produce more complex geometric figures or common objects (Trojano and Grossi, 1998).

Drawing tasks have achieved a central position in neuropsychological testing by virtue of their sensitivity to many different kinds of deficits. This sensitivity may be the reason that the discriminating power of drawing tasks at times has assumed mythic proportions. Unfortunately, it has not been uncommon for some psychologists to think that a complete neuropsychological examination consists of the WIS-A battery and one or two drawing tests, usually the Bender Gestalt and a human figure drawing (e.g., C. Piotrowski and Keller, 1989; C. Piotrowski and Lubin, 1990). Although they are rich sources of data, drawing tests have limits to the amount of information that they can provide. The examiner who uses them needs to remember that every kind of drawing task has been performed successfully by cognitively impaired patients, including some patients with lesions that should have kept them from drawing well. Furthermore, no matter how sensitive these tests might be to perceptual, practic, and certain types of cognitive and motor organization impairment, they still leave many cognitive functions unexamined.

In drawings, the phenomenon of spatial hemi-inattention—more common after right than after left hemisphere lesions—tends to be reflected in the omission of details on the side of the drawing opposite the lesion (see Figs. 3.13, 3.15a, 10.9, pp. 67, 69, 386; Behrmann and Plaut, 2001; Colombo et al., 1976; McCarthy and Warrington, 1990). Frederiks (1963) reported that free drawings (i.e., drawing to command) tend to elicit evidence of inattention more readily than does copying from a model. Patients with unilateral lesions tend to position their drawings on the same side of the page as their lesions, thus underutilizing the side of space that is most susceptible to inattention (Gasparrini et al., 1980; Gur et al., 1977; see Chapter 10, Fig. 10.9). This tendency was much more prominent in patients with left than with right hemisphere lesions, perhaps because those with left-sided damage were more likely to use a smaller part (typically the upper left quadrant and immediately adjacent areas) of the page, whereas patients in the right-lesioned group (whose drawings, both free and copy, tend to be larger than those of patients with left-sided lesions [Larrabee and Kane, 1983]) covered most of the page with their drawings, making the overall shift to the right of the midline less apparent.

When using drawings to test for visuospatial inattention, a complete copy in a single drawing does not rule out the possibility that the patient suffers unilateral inattention, as this phenomenon—particularly in its milder forms and with relatively simple drawings—may not show up consistently (see pp. 385–386). Examining for inattention requires a variety of tests.

When evaluating patients' drawings the integrity of primary visual and motor systems must also be assessed (Beaumont and Davidoff, 1992). The motor competence of the hand used in drawing is also relevant to the quality of the drawing. In contrast to Semenza, Denes, and their colleagues (1978) who found no differences between preferred and nonpreferred hands in the way in which normal subjects approached the task of copying a relatively simple figure, Bush (2000) noted significant differences between clock drawings done by the dominant and nondominant hands of patients on a subacute medical rehabilitation unit.

Copying

Bender-Gestalt Test (L. Bender, 1938; Hutt, 1985)

The *Bender-Gestalt* was one of the first and most widely studied tests of drawing. Conceptual approaches to the interpretation of nonobjective drawings that have evolved out of work on this test can be applied to the evaluation of drawing performances in general. This test, usually referred to as "The Bender," serves not only as a visuoconstructional task for neuropsychological assessment but also as a neuropsychological screening measure and as a projective technique for studying personality. The Bender's quick and easy administration probably contributed to its longstanding position as one of the most widely used psychological tests in the United States (C. Piotrowski and Keller, 1989; C. Piotrowski and Lubin, 1990). Recent surveys suggest that the Bender-Gestalt remains popular among clinical psychologists in independent practice, for whom it is the fifth most frequently used test, but neuropsychologists—who rank it only twenty-fifth in frequency of use—are much less likely to include it now in test batteries than previously (Camara et al., 2000; K. Sullivan and Bowden, 1997).

The Bender material is a set of nine designs originally used by Wertheimer (1923) to demonstrate the tendency of the perceptual system to organize visual stimuli into *Gestalten* (configurational wholes) (see Fig. 14.1). Lauretta Bender assembled these designs (labeled A and 1 through 8) for the study of visuoperceptual and visuomotor development in children, calling this method a "Visual Motor Gestalt Test." She standardized the test on 800 children in the 4–11 age range. Gradually, use of the test was extended from children to adolescents and then to adults.

Reliable evaluation of drawing distortions requires exact reproductions of the test stimuli. If the circles of design 2, for example, are depicted as ovals or the line quality of the model designs is uneven, then the examiner is hard put to decide whether similar distortions in a patient's copy represent distortion or finicking accuracy. Also, if the curves of design 7 do not cross in such a way that the figure can be seen as either two continguous or two overlapping sinusoidal curves, then the examiner cannot find out whether the patient would perceive the original curves in a simplified (uncrossed) or complex (crossed) manner.

Administration. Bender administration begins with the examiner laying three sharpened soft lead pencils with erasers and a small stack of unlined plain white letter-size paper so that the short side faces the patient.

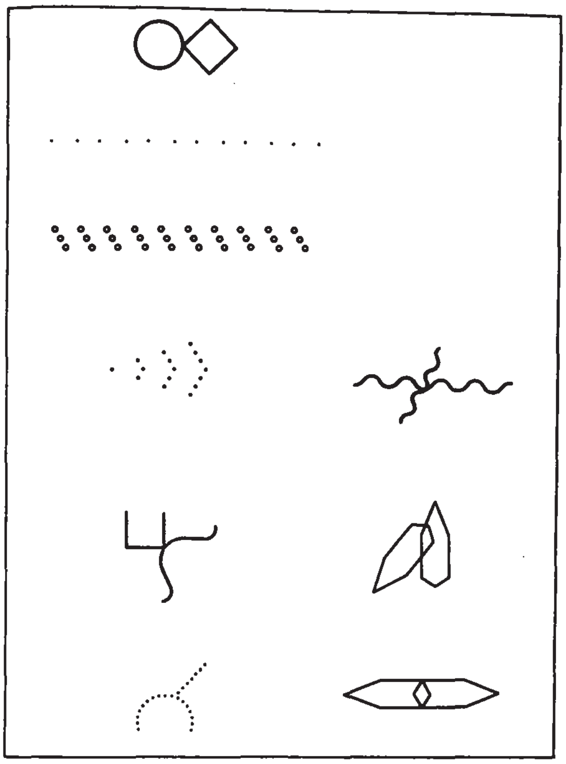


FIGURE 14.1 The Hutt adaptation of the Bender-Gestalt figures. (Hutt, 1977. Reproduced by permission)

Hard pencils tend to resist pressure so that drawing becomes more effortful and the pencil marks are less apt to reflect individual pressure differences in their shading or thickness (these materials are also appropriate for most other drawing tasks). The main purpose of putting out more than one piece of paper is to create a softer drawing surface that will increase ease of drawing and pick up pressure marks on the second sheet. Some patients set aside the top sheet of paper on completion of the first drawing or after three or four drawings. When they do, the examiner can ask them to draw all the designs on the first sheet unless no usable space remains, in which case they should complete the test on the second sheet. Forcing patients to confine their drawings to one or, at the most, two sheets provides one way to see how—or whether—they organize the designs within limited space. When not informed at the outset about placing all the designs on one page some patients will make overly large copies of the first two or three designs despite the following instructions:

> I've got nine of these altogether (hold up the pack of cards with the back facing the patient). I'm going to show them to you one at a time and your job is (or "you are") to copy them as exactly as you can. The first card is then placed on the table with its length facing the patient and its edges squared with the edges of the work surface. When patients have finished the first drawing, the second card is placed on

top of the first and so on to completion. When all the designs have been copied, patients can be asked to write their name and the date on the paper with no instructions about where these should be placed, and no suggestions if asked.

These instructions afford patients the barest minimum of structure and virtually no information on how to proceed. This method makes it a test of the abilities to organize activities and space as well. By letting subjects know there are nine cards, the examiner gives them the opportunity to plan ahead for their space needs. By not making reference to what is on the cards (e.g., by not calling them "designs"), subjects are less likely to demur or feel threatened because they do not consider themselves "artists." By lining the cards up with the edges of the work surface, the examiner provides an external anchoring point for the angulation of the stimulus so that, should subjects rotate their copy of the design, the examiner knows exactly how much the drawing is angled relative to the original stimulus.

Many subjects need no more instruction than this to complete the test comfortably. Others ask questions about how to draw the figures, whether they can be larger or smaller, have more or fewer dots, need to be numbered, lined up along the edge, or spread over the page, etc. To each of these questions, the answer is, "Just copy the card as exactly as you can." For subjects who continue to ask questions, the examiner should say, "I can only give you these instructions; the rest is up to you." Subjects who ask to erase are given permission without special encouragement. Those who attempt to turn either the stimulus card or the sheet of paper should be stopped before beginning to copy the card when it has been placed at an incorrect or uncommon angle, as the disorientation of the drawing might no longer be apparent when the paper is righted again. The page should not be turned more than is needed for a comfortable writing angle. Total copy usually runs from five to ten min.

In addition to variants of the standard administration, there are a number of other ways to give the test, most of which were developed for personality assessment (Hutt, 1985). Those that enable the examiner to see how well the subject can function under pressure provide interesting neuropsychological data as well. For instance, in the "stress Bender," the patient is given the whole test a second time with instructions to "copy the designs as fast as you can. You drew them in ___ seconds (any reasonable time approximation will do) the first time; I want to see how much faster you can do them this time." The examiner then begins timing ostentatiously. Some patients who can compensate well for mild constructional disabilities when under no pressure will first betray evidence of their problem as they speed up their performance. Interestingly, many neurologically intact subjects actually improve their Bender performance under the stress condition.

Seeking to increase the sensitivity of this task, McCann and Plunkett (1984) gave three other administrations in addition to the standard one: recall following a 10 sec delay; drawing with the nonpreferred hand; and the "perfect" method, in which subjects are shown their standard administration along with the stimulus cards and asked to make a new copy, correcting any initial errors they find. All of these methods discriminated beyond chance among 30 Korsakoff patients, 30 with paranoid schizophrenia, and 30 healthy control subjects. The "perfect" method proved to be the most sensitive, correctly identifying 93% of the patient group relative to controls, but none of the methods successfully discriminated the two patient groups from each other.

Wepman (personal communication, 1974 [mdl]) incorporated two recall procedures into his three-stage standard administration of the Bender. Each card is shown for five seconds, then removed, and the subject is instructed to draw it from memory. After this, the cards are shown again, one at a time, with instructions to copy them exactly (as in the standard copy administration). In the third stage, the subject is handed another blank sheet of paper and is asked to draw as many of the figures as can be recalled. Wepman viewed difficulty with items 1, 2, 4, and 5 as particularly suggestive of a constructional disorder. He found that healthy subjects typically recall five designs or more, and he considered recall scores under five to be suggestive of brain impairment. Data from others are consistent with Wepman's observations (Lyle and Gottesman, 1977; Pirozzolo, Hansch, et al., 1982; Schraa et al., 1983). My [mdl] experience in giving a 30-min delay trial suggests that, like the delay trial for the Complex Figure, most subjects continue to retain most if not all of what they recalled immediately. Administration and scoring procedures of the many reported studies have not been standardized, leaving important questions unanswered, such as how many designs would be recalled by healthy adults after interference or a delay and how strict the scoring criteria should be.

Scoring systems. Lauretta Bender (1946) conceived of her test as a clinical exercise in which "(d)eviate behavior . . . should be observed and noted. It never represents a test failure." Consequently, she did not use a scoring system. Potential test variables are numerous and equivocal, and their dimensions are often difficult to define. The profusion of scoring possibilities has resulted in many attempts to develop a workable system to obtain scores for diagnostic purposes.

One of the earliest scoring systems for adults was devised by Pascal and Suttell (1951), who viewed deviations in the execution of Bender drawings as reflecting "disturbances in cortical function," whether on a psychiatric or neurological basis. The Pascal-Suttell system identifies 106 different scorable characteristics of the Bender drawings, from 10 to 13 for each figure (excluding A) plus seven layout variables applied to the performance as a whole. With each deviant response given a numerical value, the examiner can compute a score indicating the extent to which the drawings deviate from normal copies. An examiner who knows the Pascal-Suttell system can score most records in two to three minutes. Despite the apparent complexity of the Pascal-Suttell scoring system, a factor analysis by E.E. Wagner and Marsico (1991) found that performance on the Bender-Gestalt was reducible to a single general factor (reproductive accuracy). The highest scores tend to be obtained by patients with known brain disorders, but the considerable overlap between groups of neurologic and psychiatric patients makes differentiation between them on the basis of the Pascal-Suttell score alone very questionable.

Hutt (1985) also examined Bender performance as a whole in designing his 17-factor Psychopathology Scale. Five of Hutt's factors relate to the organization of the drawings on the page and their spatial relationships to one another, four to changes in the overall configuration ("gestalt") of a drawing (i.e., difficulties with closure, crossing, curvature, and angulation), and eight to specific distortions (e.g., fragmentation, perseveration). He identified 11 types of deviations as likely indicators of CNS pathology, particularly if four or more are present in a given patient's record: collision (overlapping) of discrete designs; marked angulation difficulty; severe perceptual rotation; simplification; severe fragmentation; moderate to severe difficulty with overlapping figures; severe perseveration; moderate to severe elaboration; redrawing of a complete figure; line incoordination; and concreteness. A careful reading of Hutt's description and interpretation of these deviant characteristics will enhance the examiner's perceptiveness in dealing with Bender data (see Hutt and Gibby, 1970, for examples). Hutt also described a number of other characteristic distortions—such as size changes and line quality—that are not included in his 17-factor scale but may be associated with neurologic conditions affecting brain function and have been included in one or more other scoring systems.

Scores on all but one of Hutt's factors range from 10 to 1, the exception being the second factor (position of the first drawing), which has only two scale values—3.25 for Abnormal and 1.0 for Normal. Scores range from 17 for a perfect performance (or at least a performance without scorable imperfections) to 163.5 for a performance in which maximum difficulty is encountered in handling each characteristic. Criteria for scoring each factor are presented in detail and are sufficiently clear to result in reliable judgments. Hutt reported interrater reliability coefficients for the 17 factors for two judges (scoring 100 schizophrenic patient records) ranging from 1.00 to .76, with five factor correlations running above .90 and nine above .80. An interrater reliability coefficient of .96 was obtained for the total scale. Lacks (1999) subsequently elaborated upon the Hutt scoring system and also collected extensive normative data on healthy adults that are representative of the age, sex, race, and educational characteristics of the U.S. population. In a comparison of scoring procedures, the Pascal-Suttell system was slightly more accurate than Lack's adaptation of Hutt's scale in classifying patients, but the latter was easier to use (Marsico and Wagner, 1990).

Although a reliable scoring system is necessary when doing research with the Bender, qualitative inspection of the patient's designs is usually sufficient for clinical purposes. Familiarity with one or more of the scoring systems will make the examiner aware of common Bender distortions and the kinds of aberrations that tend to be associated with visuospatial impairment and other symptoms of brain dysfunction. Blind reliance on Bender test scores, without adequate attention to the qualitative aspects of a patient's performance, can lead to erroneous conclusions about the absence of brain impairment, as illustrated by normal scores obtained by E.W. Russell's (1976) aphasic patient with pronounced right hemiplegia who had sustained a severe depressed skull fracture some 17 years earlier, and Bigler and Ehrfurth's (1980) three patients with CT documented brain damage who also received scores *within normal limits*.

Test characteristics. Most nine-year-olds can copy the Bender designs with a fair degree of accuracy, and by age 12, healthy youngsters can copy all of the designs well (Koppitz, 1964). Lacks and Storandt (1982) reported decrements in Bender-Gestalt performance when individuals enter their 60s to 70s. However, a review of seven smaller studies using a modification of Hutt's scoring system (Hutt-Briskin) did not find any regular age related score decrements (J.B. Murray, 2001). Bender-Gestalt performance is also influenced by cognitive ability, as evidenced by mean score differences between high school- and college-educated populations in Pascal and Suttell's (1951) sample—significant differences also observed in more recent studies (years 1985 to 1991) (J.B. Murray, 2001).

Neuropsychological findings. Like other visuographic deficits, difficulties with the Bender are more likely to appear with parietal lobe lesions (F.W. Black and Bernard, 1984; Garron and Cheifetz, 1965); lesions of the right parietal lobe are associated with the poorest performances (Diller, Ben-Yishay, et al., 1974; Hirschenfang, 1960a). A normal appearing Bender clearly does not rule out CNS pathology, but it does reduce the likelihood of parietal involvement. Patients with right hemisphere damage are more susceptible than those with left-sided lesions to errors of rotation (Billingslea, 1963) and fragmentation (Belleza et al., 1979). Diller and Weinberg (1965) asserted that omission errors would only be made by patients with right hemisphere lesions, but in my [mdl] experience, patients with either right- or left-sided lesions—and certainly those with bilateral damage—make these errors.

Bender error scores distinguished Alzheimer patients from healthy control subjects (Storandt, Botwinick, and Danziger, 1986). For elderly psychiatric patients, Bender errors were significantly related to scores on a mental status examination ($r = .60$) (Wolber, Romaniuk, et al., 1984) and to ratings of activities of daily living ($r = .62$) (Wolber and Lira, 1981). Bender error scores also predicted the level of independent living that TBI patients would achieve approximately three to four years after their accident ($r = .40, p < .001$) (M.B. Acker and Davis, 1989). The sensitivity of this test to diffuse cortical disease and to subcortical lesions (Lyle and Gottesman, 1977) suggests that copying tasks require a high level of integrative behavior that is not necessarily specific to visuographic functions but tends to break down with many kinds of cerebral damage.

Finally, scores on the Bender-Gestalt have been sensitive to changes in neuropsychological status. They faithfully reflected the deteriorating cognitive status of Alzheimer patients over time (Storandt, Botwinick, and Danziger, 1986). They also registered improved cognitive function in alcoholics who became abstinent (R.H. Farmer, 1973).

Benton Visual Retention Test (BVRT): Copy Administration (Sivan, 1992)

The three alternate forms of this test permit the use of one of them for a copy trial (see p. 462 for a description and picture of the test). The copy trial usually precedes the memory trials, thus allowing the subject to become familiarized with the test before undertaking the more difficult memory trials. Benton's original normative population of 200 adults provides the criteria for evaluating the scores (see pp. 462–464 for scoring details). Each subject's drawings are evaluated according to the estimated original level of functioning. Persons of *average* or better mental ability are expected to make no more than two errors. Subjects making three or four errors who typically perform at *low average* to *borderline* levels on most other cognitive tasks have probably done as well as could be expected on this test; for them, the presence of a more than ordinary number of errors does not signify a visuographic disability. In contrast, the visuographic functioning of subjects whose scores on other kinds of tasks range above *average* and who make four or five errors on this task is suspect.

Neuropsychological findings. The performance of patients with frontal lobe lesions differed with the side of injury: those with bilateral damage averaged 4.6 errors; with right-sided damage, 3.5 errors; and with left-sided damage the average 1.0 error is comparable to that of the normative group (Benton, 1968). Other studies support a right–left differential in defective copying of these designs, with right hemisphere patients two or three times more likely to have difficulties (Benton, 1969a). However, in one study that included aphasic patients in the comparisons between groups with lateralized lesions, no differences were found in the frequency with which constructional impairment was present in the drawings of right and left hemisphere damaged patients (Arena and Gainotti, 1978). Error scores for Alzheimer patients virtually skyrocketed from their initial examination when their condition was diagnosed as mild ($M = 3.3 \pm 5.1$) to two-and-one-half years later ($M = 13.5 \pm 1.7$), in sharp contrast to healthy matched subjects whose first "nearly perfect" copy error scores ($M = 0.6 \pm 0.8$) did not differ significantly from the later one ($M = 0.8 \pm 1.5$) (Storandt, Botwinick, and Danziger, 1986). Although all scores other than *Perseverative errors* were associated with dementia severity in Alzheimer patients, *Omission errors* showed the greatest increase across dementia severity (Robinson-Whelen, 1992). BVRT copy is one of the predictors of cognitive decline in Alzheimer's disease, with poorer copy associated with a faster rate of dementia progression (Rasmusson, et al., 1996).

Complex Figure Test (CFT): copy administration

A "complex figure" was devised by André Rey (1941; translated by Corwin and Bylsma, 1993b) to investigate both perceptual organization and visual memory in brain impaired subjects (Fig. 14.2; see pp. 457–461 for a discussion of CFT memory testing). Osterrieth (1944; translated by Corwin and Bylsma, 1993b) standardized Rey's procedure; developed the widely used 18-item, 36-point scoring system; and obtained nor-

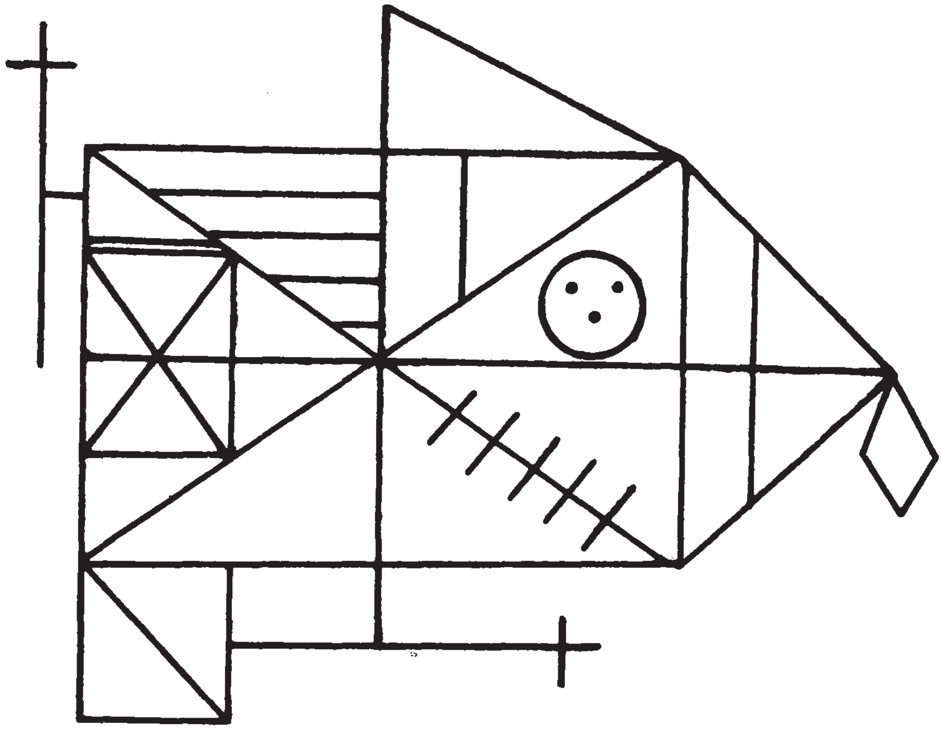


FIGURE 14.2 Rey Complex Figure (actual size). (Osterrieth, 1944)

mative data from the performances of 230 normal children ranging in age from four to 15 years and 60 adults in the 16–60-year age range. Because of Osterrieth's significant contribution, the Rey figure is also often called the Rey-Osterrieth, "Rey-O", or simply "CFT-R-O". L.B. Taylor (1979) developed an alternative complex figure for use in retesting (Fig. 14.3), which has been subsequently modified to improve its equivalence to the Rey-Osterrieth figure (Hubley and Tremblay, 2002) (Fig. 14.4).

The Medical College of Georgia (MCG) Neurology group developed four complex figures for repeated assessments (e.g., see Fig. 14.5*a–d*). Two of the MCG figures are rectangular in orientation—like the Rey-Osterrieth figure, and two are square—as is the Taylor figure. The MCG figures use a 36-point scoring system to facilitate comparison with the Rey-Osterrieth or Taylor figures (Loring and Meador, 2003a; Meador, Moore, Nichols, et al., 1993). A separate complex figure with a maximum score of 20 is part of the *Repeatable Brief Assessment of Neuropsychological Status* (*RBANS*) (C. Randolph, 1998); see pp. 696–697.

The copy task is simply that: copying the complex figure onto a sheet of paper. The figure is placed so that its length runs along the subject's horizontal plane. The patient is not allowed to rotate either the design or the paper. Copy orientation may be less critical than originally thought, however, as one study reports no performance difference when copied at various orientations (0, 90°, 180°, or 270°) (Ferraro et al., 2002). This permits CFT use with greater confidence in less than optimal conditions such as bedside testing. Some examiners use photocopied sheets with the figure at the top portion of the page, and patients make their copies in the lower half of the paper. For persons unaccustomed to using a pencil, Dr. Harmesh Kumar recommends they be given the copy trial twice (personal communication, Feb., 2000 [mdl]).

Several methods may be used to record how the subject proceeds. Each time a portion of the drawing is completed, the examiner gives the subject a different colored pencil (or pen) while noting the order of color use. Some examiners prefer to change colors at fixed intervals (e.g., every 30 sec). Another method involves keeping a detailed record of each subject's copying sequence by copying what the subject draws and numbering each unit in the order that it is drawn, or using a "registration sheet" containing the printed Rey figure on which the examiner numbers in the order in which subjects make their copies (R.S.H. Visser, 1973;

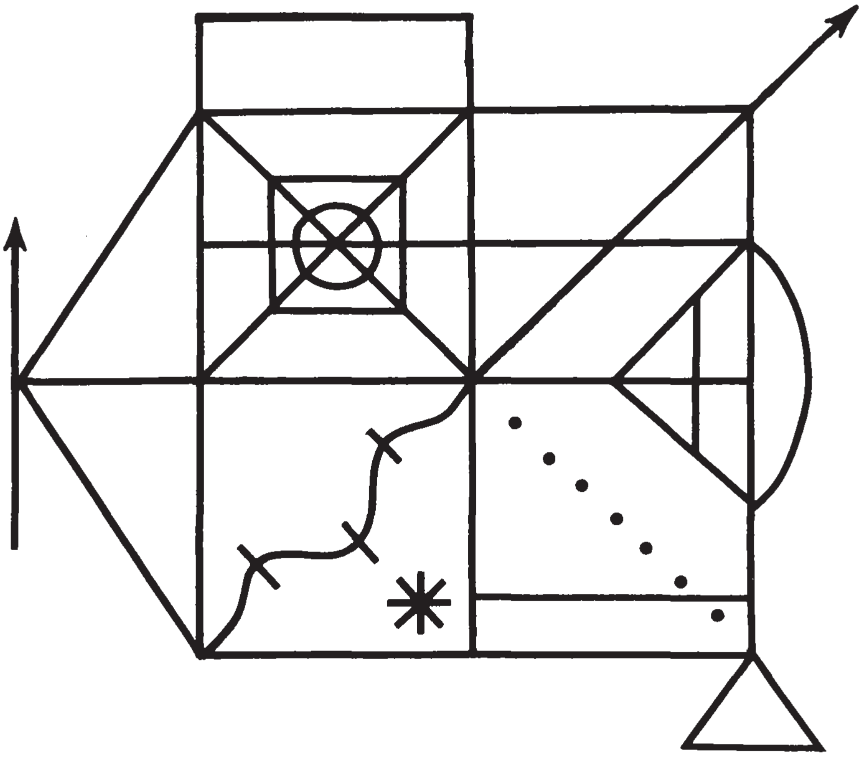


FIGURE 14.3 Taylor Complex Figure (actual size).

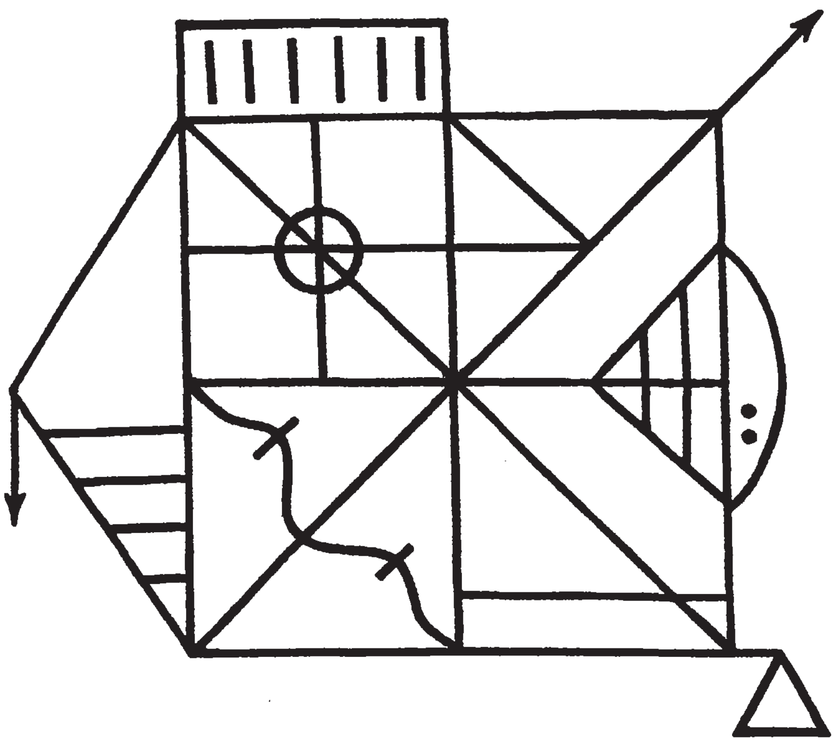
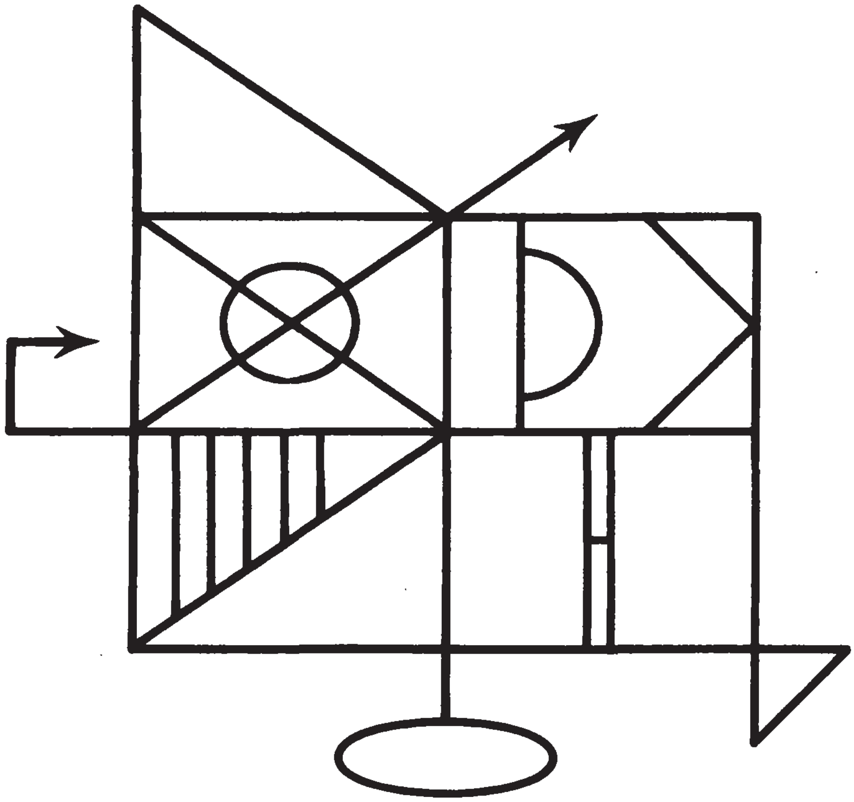


FIGURE 14.4 *Modified Taylor Figure.* (Hubley and Tremblay, 2002. © Anita Hubley. Reproduced by permission. This figure may be reproduced but may not be sold.)



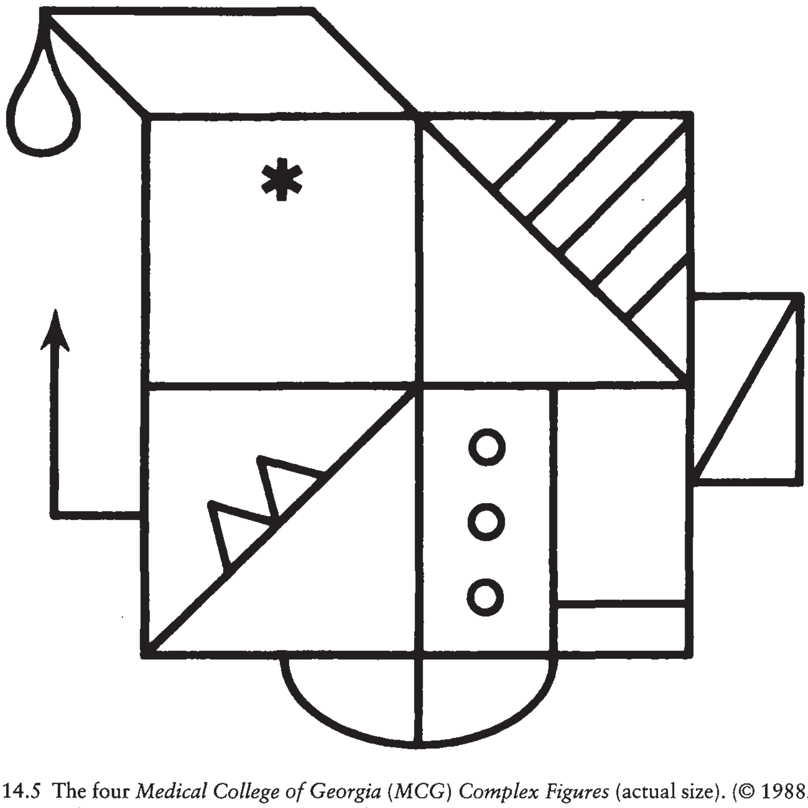
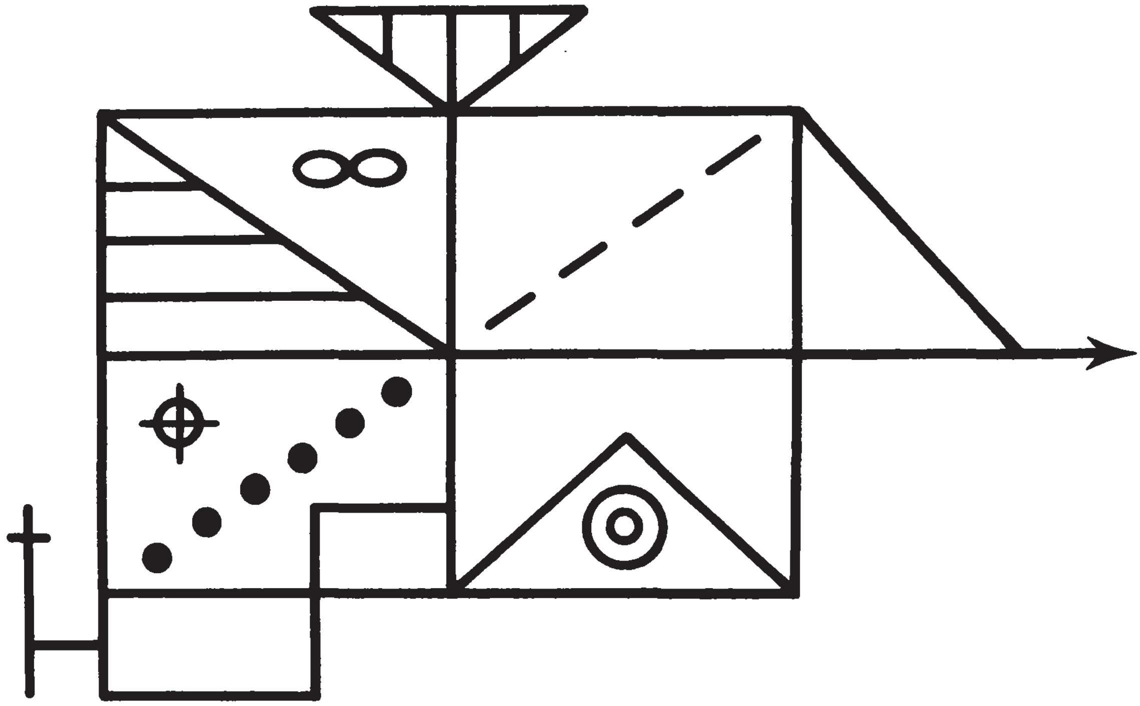


FIGURE 14.5 The four *Medical College of Georgia (MCG) Complex Figures* (actual size). (© 1988, 1989, 1990 K.J. Meador, Taylor, and Loring. Reproduced by permission.)

(continued)



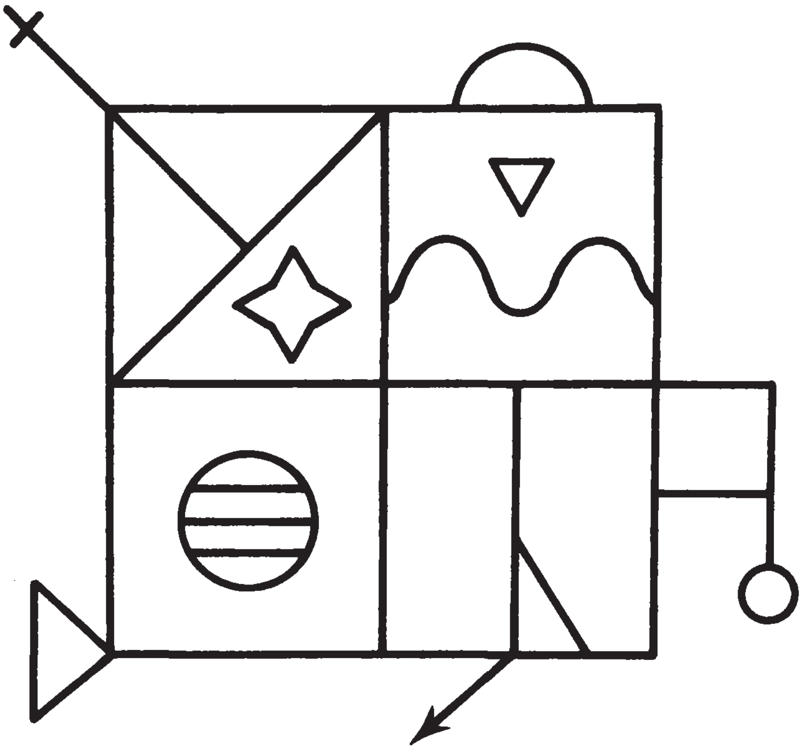


FIGURE 14.5 (Continued)

e.g., see Spreen and Strauss, 1998, pp. 342-347). For most purposes, switching colors generally affords an adequate and less cumbersome record of the subject's strategy or lack thereof. J.E. Meyers and Meyers (1995b) suggested that pen switching may be overly distracting for some patients, yet J.S. Ruffolo, Javorsky, and their colleagues (2001) found that pen switching was associated with better performance. The technique of drawing exactly what the subject draws and numbering each segment will best preserve the drawing sequence precisely (directional arrows can be useful). A registration sheet will work only for subjects whose copy is reasonably accurate; this method will not suffice for very defective copies, especially those with repeated elements or marked distortion of the basic structure (e.g., see Fig. 14.6). Some examiners also record time to completion. The copy trial is typically followed by one or more recall trials. Occasionally, subjects are dissatisfied with a poorly executed copy, others produce a copy so distorted that any examination of recall based on it would be uninterpretable, and still others begin the copy in such a manner that halfway through the task they realize they cannot make an accurate copy and ask to redo it (e.g., see Fig. 7.2, p. 240). In these cases, a second copy trial can be given if there seems to be any likelihood of improvement the second time.

Scoring systems. Although several scoring systems have been published, the most commonly used continues to be the Rey-Osterreith/Taylor/MCG unit scoring method which divides the figures into 18 scorable units (see Tables 14.1 to 14.4). These units refer to specific areas or details of the figures, with each unit numbered for scoring convenience. Since a correctly placed and proportional copy of each unit earns 2 points, the highest possible score is 36. Spreen and Strauss (1998, pp. 342–347) provide useful formats for scoring the Rey-Osterrieth, Taylor, and MCG figures using this system.

How investigators interpret and apply the scoring criteria can vary. Since subjective judgment often comes into play, whether a "strict" or "lenient" rating is used will affect the final scores. Often, a stricter scoring approach is used for the copy trial (e.g., following the

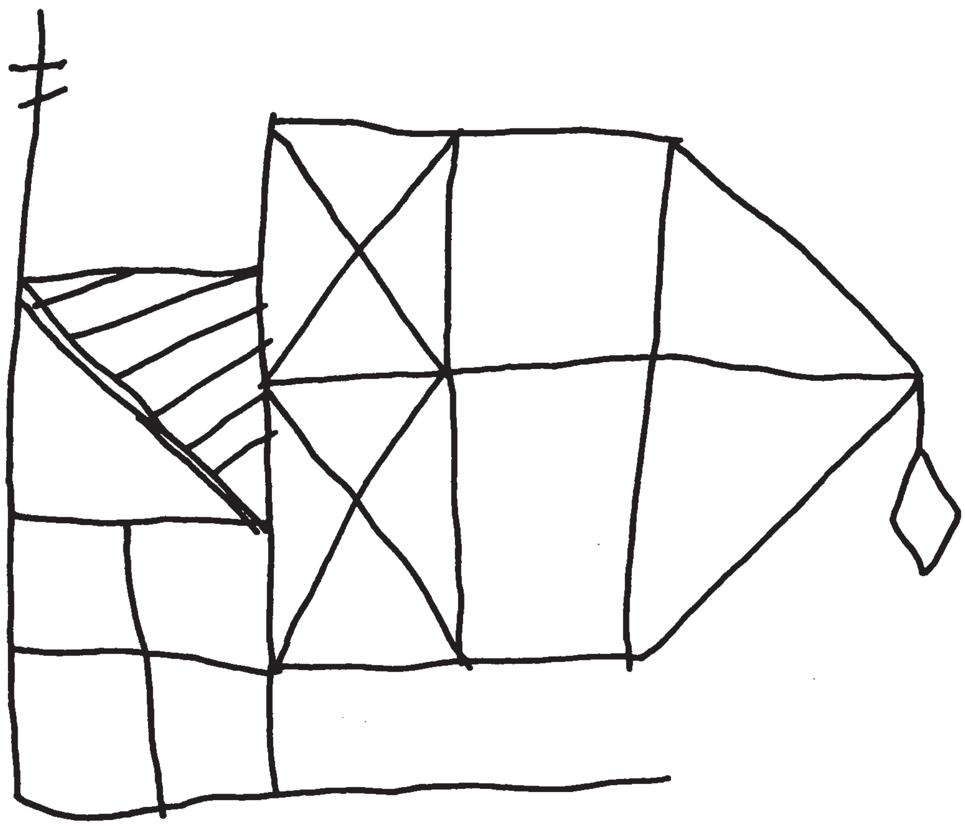


FIGURE 14.6 An example of a *Complex Figure Test Rey-Osterrieth* copy which would be difficult to document on a "registration" sheet due to fragmentation, broken configuration, and the several repetitions.

TABLE 14.1 Scoring System for the Rey Complex Figure

Units

1. Cross upper left corner, outside of rectangle
2. Large rectangle
3. Diagonal cross
4. Horizontal midline of 2
5. Vertical midline
6. Small rectangle, within 2 to the left
7. Small segment above 6
8. Four parallel lines within 2, upper left
9. Triangle above 2, upper right
10. Small vertical line within 2, below 9
11. Circle with three dots within 2
12. Five parallel lines within 2 crossing 3, lower right
13. Sides of triangle attached to 2 on right
14. Diamond attached to 13
15. Vertical line within triangle 13 parallel to right vertical of 2
16. Horizontal line within 13, continuing 4 to right
17. Cross attached to 5 below 2
18. Square attached to 2, lower left

Scoring

Consider each of the 18 units separately. Appraise accuracy of each unit and relative position within the whole of the design. For each unit count as follows:

Correct	placed properly	2 points
	placed poorly	1 point
Distorted or incomplete but recognizable	placed properly	1 point
	placed poorly	½ point
Absent or not recognizable		0 points
Maximum		36 points

From E.M. Taylor (1959), adapted from Osterrieth (1944)

TABLE 14.2 Scoring System for the Taylor Complex Figure

Units

1. Arrow at left of figure
2. Triangle to left of large square
3. Square, which is the base of figure
4. Horizontal midline of large square, which extends to 1
5. Vertical midline of large square
6. Horizontal line in top half of large square
7. Diagonals in top left quadrant of large square
8. Small square in top left quadrant
9. Circle in top left quadrant
10. Rectangle above top left quadrant
11. Arrow through and extending out of top right quadrant
12. Semicircle to right of large square
13. Triangle with enclosed line in right half of large square
14. Row of 7 dots in lower right quadrant
15. Horizontal line between 6th and 7th dots
16. Triangle at bottom right corner of lower right quadrant
17. Curved line with 3 cross-bars in lower left quadrant
18. Star in lower left quadrant

Scoring

Follow instructions given in Table 14.1 for scoring the Rey figure.

TABLE 14.3 Modified Taylor Figure

Units

1. Large square
2. Crossed diagonal lines in 1
3. Horizontal midline of 1
4. Vertical midline of 1
5. Short horizontal line in upper right quadrant
6. Short diagonal line in upper right quadrant
7. Diagonal arrow attached to corner of 1
8. Triangle in 1 on right, two vertical lines included
9. Semicircle attached to right side of 1, two dots included
10. Triangle attached to 1 by horizontal line
11. Horizontal line in lower right quadrant
12. Wavy line, includes two short lines
13. Large triangle attached to left of 1
14. Four horizontal lines within 13
15. Arrow attached to apex of 13
16. Horizontal and vertical lines in upper left quadrant
17. Circle in upper left quadrant
18. Small rectangle above 1 on left, six lines included

Modified Taylor Complex Figure (MTCF); Copyright A.M. Hubley, 1996, 1998. Reproduced by permission. This figure may be reproduced but may not be sold.

practice at the Montreal Neurological Institute: Marilyn Jones-Gotman, personal communication, 1988 [mdl]), and a more lenient one for recall so as to not overly penalize memory performance based upon constructional accuracy alone. Bennett-Levy (1984a) offered some guidelines for "lax" scoring, and an explicit set of lenient scoring criteria was provided by Loring, Martin, and their colleagues (1990). Guyot and Rigault (1965) recommended scoring each element in terms of its relation to contiguous elements, with clearly depicted diagrams of the 18 scored Rey-Osterrieth elements and their contiguous relations. Both Loring, Martin, and colleagues, and Guyot and Rigault reminded examiners to avoid penalizing the same error twice (e.g., if the triangle above the large rectangle is misplaced, then the rectangle does not get marked down for misplacement too). Explicit scoring criteria are given by Duley and his colleagues (1993) for both the Rey-Osterrieth and Taylor figures.

TABLE 14.4 Scoring Systems for the MCG Complex Figures

MCG COMPLEX FIGURE 1

Units

1. Large rectangle
2. Vertical midline of 1
3. Horizontal midline of 1
4. Small triangle on right hand corner of 1
5. Oval and attaching line at the bottom of 1
6. Bent arrow to the left of 1
7. Triangle above left upper quadrant of 1
8. Tilted arrow at top of 1
9. Diagonal in upper left quadrant of 1
10. Second diagonal in left quadrant of 1
11. Circle in upper left quadrant of 1
12. Diagonal in lower left quadrant of 1
13. Five vertical lines extending above 12
14. Vertical lines and horizontal connection ("H") in lower right quadrant of 1
15. Vertical line in right upper quadrant of 1
16. Semicircle attached to the right of 15
17. Diagonal line at upper right corner of 1
18. Diagonal line extending from 17 to 3

MCG COMPLEX FIGURE 2

1. Large square
2. Vertical midline for 1
3. Horizontal midline for 1
4. Asterisk in the upper left quadrant of 1
5. Diagonal in the lower left quadrant of 1
6. Two triangles attached to 5
7. Three circles in the lower right quadrant of 1
8. Vertical midline in the lower right quadrant of 1
9. Horizontal line to the right of 8
10. Diagonal line in the upper right quadrant of 1
11. Five diagonal lines perpendicular to 10
12. Small rectangle to the right of 1
13. Diagonal line in 12
14. Semicircle at the base of 1
15. Vertical line in 14
16. Angled arrow to the left of 1
17. Parallelogram above 1
18. Teardrop attached to 17

MCG COMPLEX FIGURE 3

Units

1. Large rectangle
2. Vertical midline of 1
3. Horizontal midline of 1
4. Diagonal line in left upper quadrant of 1
5. Three horizontal lines extending to 4
6. Infinity sign in left upper quadrant of 1
7. Circle and cross in lower left quadrant of 1
8. Six diagonal dots in lower left quadrant of 1
9. Small rectangle in lower left quadrant of 1
10. Small rectangle extending from bottom of 1
11. Cross attached to 10
12. Right angle in lower right quadrant of 1
13. Two concentric circles places under 12
14. Four dashed lines in upper right quadrant of 1
15. Triangle atop 1
16. Three vertical lines in 15
17. Triangle to the right of 1
18. Arrow attached to the right of 17

MCG COMPLEX FIGURE 4

Units

1. Large square
2. Vertical midline of 1
3. Horizontal midline of 1
4. Rectangle to the right of 1
5. Circle with stem attached to 4
6. Angled arrow at bottom of 1
7. Small triangle outside lower left corner of 1
8. Cross outside of upper left corner of 1
9. Semicircle on top of 1
10. Diagonal line in the upper left quadrant of 1
11. Perpendicular line to 10
12. Star in the upper left quadrant of 1
13. Circle in the lower left quadrant of 1
14. Three horizontal lines inside of 13
15. Small triangle in upper right quadrant of 1
16. Sine wave in upper right quadrant of 1
17. Vertical midline of the lower right quadrant
18. Diagonal line extending to the right of 17

Scores for copy trials of the Rey-Osterrieth, Taylor, and MCG figures tend to be comparable, although recall of the Rey-Osterrieth appears to be more difficult than that of either the Taylor or MCG figures, which tend to be roughly equivalent (see p. 458). Hamby and her colleagues (1993) note that it is easier to make a well-organized copy of the Taylor figure since its structure is simpler than that of the Rey-Osterrieth.

Fastenau, Denburg, and Hufford (1999) offer norm sets based on 211 "healthy adults" in the 30–85 age range, using the original Rey-Osterrieth scoring system (18 items, 36 points) and converted standard scores. With 43 to 102 subjects in eight overlapping age groups, these are probably the best norms currently available, at least for the U.S. Spreen and Strauss (1998) give means and standard deviations for each year from 6 to 15 and five age ranges from 16–30 to 70+.[1] The children's norms are based on hundreds of subjects, but the norms from 50–59 to 70+ must be considered only provisional because of scanty numbers. Mitrushina, Boone, and D'Elia (1999) offer a compilation of normative studies. Ingram and colleagues (1997) produced norms for older persons ages 55 to 75 for two MCG figures.

An 11-point system was developed for scoring qualitative errors most commonly made by patients with right hemisphere lesions (Loring, Lee, and Meador, 1988). Specific scoring criteria are given by Loring and his colleagues for each of 11 errors (identified by roman numerals to distinguish them from the numbered scoring elements of the Rey-Osterrieth system) (see Table 14.5). More than twice as many patients with right temporal epileptic foci made two or more of these errors than did patients whose seizure focus involved the left temporal lobe. In a cross-validation study, 66% of patients with temporal lobe epilepsy were correctly classified with respect to side of lesion on the basis of qualitative scores alone, with a sensitivity of 50% and specificity of 77% (Piguet et al., 1994). These qualitative errors, however, are also common in the recall of patients with diffuse impairment such as those with early dementia (dwl).

Denman (1987) scored the Rey figure for 24 elements, each on a 3-point scale yielding a maximum score of 72. Tombaugh, Faulkner, and Hubley (1992) produced a parallel system for scoring the Taylor figure. However, since the 18-element and the 24-element scoring systems generate virtually equivalent results (Rapport, Charter, et al., 1997; Tombaugh and Hubley, 1991), the extra time and effort required by a more complex scoring system do not appear to be justified.

Waber and Holmes (1985, 1986) used three scores to evaluate children's drawings (see p. 546 for descriptions of their *Organization* and *Style* scores). The *Objective Rating* score comprises a number of different kinds of features: Accuracy indicates the presence or absence of individual line segments belonging to one of four major structural components (base rectangle, main substructure, outer configuration, internal detail); Alignments and Intersections comprises 24 points where lines intersect or angles are formed; Continuity of Lines identifies drawing style for lines that can be rendered either continuously or in separate segments; scored *Errors* are of four kinds: use of a single line to represent more than one part, rotation, perseveration, and misplacement.

TABLE 14.5 Scoring System of Qualitative Errors

I.	Diamond attached by stem
II.	Misplacement of the diamond
III.	Rotation of horizontal lines in upper left quadrant
IV.	Distortion of the overall configuration
V.	Major alteration of the upper right triangle
VI.	Six or more horizontal lines in upper left quadrant
VII.	Parallel lines similar to those in upper left quadrant repeated elsewhere
VIII.	Misplacement of either peripheral cross
IX.	Major mislocation
X.	Additional cross lines in either cross
XI.	Incorporation of pieces into a larger element

Abbreviated from Loring, Lee, and Meador (1988)

Evaluating strategy. Strategy and organization when copying the complex figure are important determinants for subsequent CFT recall (L.K. Dawson and Grant, 2000; B.J. Diamond, DeLuca, and Kelley, 1997; Eslinger and Grattan, 1990; Heinrichs and Bury, 1991). Evaluation techniques use more or less complex measures of the degree to which the figure was drawn in a conceptual, fragmented, or confused manner: most of them require the examiner to record the order and direction of the drawing. Such detailed measurements are not ordinarily needed for clinical purposes if the examiner either uses the colored pencil method or keeps a record of how the subject goes about copying the figure. When quantification of strategy or organization is needed, the choice of method will probably be based on the degree of specificity required. Many of the qualitative measures in current use have been summarized and compared on such characteristics as shape of distribution, convergent and discriminant validity, and interrater reliability (Troyer and Wishart, 1997).

Osterrieth (1944; see Corwin and Bylsma, 1993a) identified seven different procedural types:

(I) Subject begins by drawing the large central rectangle and details are added in relation to it. (II) Subject begins with a detail attached to the central rectangle, or with a subsection of the central rectangle, completes the rectangle and adds remaining details in relation to the rectangle. (III) Subject begins by drawing the overall contour of the figure without explicit differentiation of the central rectangle and then adds the internal details. (IV) Subject juxtaposes details one by one without an organizing structure. (V) Subject copies discrete

[1]Except where noted, all studies cited here will be based on the 18-element, 36-point scoring system for each figure.

parts of the drawing without any semblance of organization. (VI) Subject substitutes the drawing of a similar object, such as a boat or house. (VII) The drawing is an unrecognizable scrawl.

In Osterrieth's sample, 83% of the adult control subjects followed procedure Types I and II, 15% used Type IV, and there was one Type III subject. Past the age of seven, no child proceeded on a Type V, VI, or VII basis, and from age 13 onward, more than half the children followed Types I and II. No one, child or adult, produced a scrawl. More than half (63%) of the TBI group also followed Type I and II procedures, although there were a few more Type III and IV subjects in this group and one of Type V. Three of four aphasic patients and one with senile dementia gave Type IV performances; one aphasic and one presenile dementia patient followed a Type V procedure.

In line with Osterrieth's observations, R.S.H. Visser (1973) noted that "brain-damaged subjects deviate from the normals mainly in the fact that the large rectangle does not exist for them . . . [Thus] since the main line clusters do not exist, [parts of] the main lines and details are drawn intermingled, working from top to bottom and from left to right" (p. 23).

Although, like all overgeneralizations, Visser's statement has exceptions, L.M. Binder (1982) showed how stroke patients tend to lose the overall configuration of the design. By analyzing how subjects draw the structural elements of the Rey-Osterrieth figure (the vertices of the pentagon drawn together, horizontal midline, vertical midline, and two diagonals) (Fig. 14.7), Binder obtained three scores: *Configural Units* is the number of these five elements that were each drawn as one unit (best score = 5). *Fragmented Units* is the number that were not drawn as a unit (this is not the inverse of the Configural score as it does not include incomplete units, i.e., those that had a part missing) (best score = 0); and *Missing Units* is the number of incomplete or omitted units (best score = 0). Fourteen patients with left hemisphere lesions tended to display more fragmentation (M = 1.64) than the 14 with right-sided lesions (M = .71), but the latter group's Missing Units score (M = 1.71), primarily due to left-sided inattention, far outweighed the negligible Missing Units score (M = 0.07) for the left CVA group. In contrast, 14 control subjects made few (M = 0.21) Fragmented Units and omitted none. Copying impairments were reflected in low Configural Unit scores for patients with right-sided CVAs (M = 2.57) and higher Configural Unit scores for those with left CVAs (M = 3.29); the control subjects made near-perfect scores (M = 4.79). An elaboration of the original system for scoring strategic sequences includes the four sides of the rectangle and takes into account whether the internal lines are drawn after the rectangle (as do most intact subjects) or before, to arrive at a 12-point sequencing score (L.M. Binder and Wonser, 1989). This score did not differentiate postacute left- and right-side damaged stroke patients, but it did document a greater tendency for fragmentation among those with damage on the left.

Using Binder's basic approach, Parkinson patients tended to copy the main structural units of the figure poorly, in contrast to healthy elderly subjects who rarely omitted main section elements (M. Grossman, Carvell, and Peltzer, 1993). Parkinson patients also tended to draw the main elements toward the end of the trial, and this in an interrupted fashion as if main elements were incidental detail rather than critical parts of the figure's structure.

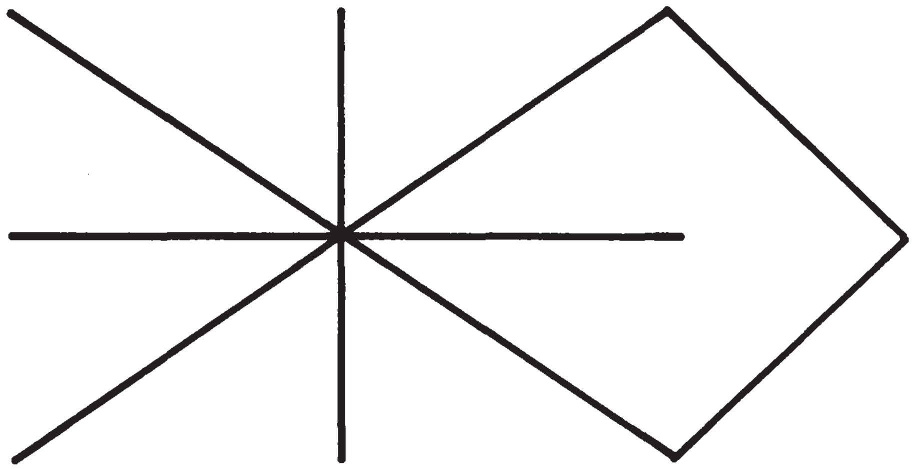


FIGURE 14.7 Structural elements of the Rey Complex Figure. (Binder, 1982)

By adding the large base rectangle to the number of main elements, Binder's method was modified slightly without compromising the attractive simplicity of a method that examines a few primary Rey-O figure features (C.R. Savage et al., 1999). Reliability coefficients are high for this modification, ranging from .69 for the vertex of the triangle to .92 for the vertical midline (Deckersbach et al., 2000). In a study of patients with obsessive-compulsive disorder (OCD), impaired complex figure recall was associated with impaired organizational strategies used during the initial copy trial (C.R. Savage et al., 1999).

Hamby and her colleagues (1993) devised a 5-point system for scoring organizational quality with criteria for both Rey and Taylor figures. They used five colors for the drawing, switching when the first element is completed, next when the subject draws a detail before the basic structure is completed or upon its completion, with the next three colors switched so that elements are divided "approximately equally" between them. Specific rules for judging *Configural mistakes, Diagonal mistakes,* and *Detail mistakes* are given. The score represents an evaluation based on the nature and number of mistakes (see Table 14.6). When Hamby and her coworkers (1993) used this score to evaluate CFT copies made by HIV positive subjects, the organization quality score of the Rey figure—but not the Taylor figure—differentiated those with AIDS related complex or AIDS from those without symptoms. This score correlated only modestly with the copy score ($r = .32$, $p < .05$).

The following three systems for evaluating strategy depend on a precise recording of the order and direction of drawing for every element.

The *perceptual cluster* score for evaluating strategy records the number of junctures (out of a possible 20) for which lines on either side are "drawn continuously or contiguously" or are fragmented into smaller parts (e.g., the two halves of the triangle on the right, the full length of each diagonal line in the left-hand box or in the major rectangle of the figure) (Shorr et al., 1992).

TABLE 14.6 Complex Figure Organizational Quality Scoring

5. No mistakes; overall organization is "excellent."
4. Detail mistakes and/or completion of upper left cross before major structures; organization is "good."
3. One configural or diagonal (e.g., lines don't cross in middle rectangle) mistake with or without detail mistakes; organization is "fair."
2. Two configural or diagonal mistakes with "poor" organization.
1. Three or more configural or diagonal mistakes; one configural or diagonal element missing, much segmentation, and "poor" organization.

Abbreviated from Hamby et al. (1993)

A *perceptual ratio* score is obtained by dividing the perceptual cluster score by the number of junctures included in the drawing. For drawings by an etiologically very mixed group of patients the perceptual ratio score's correlation with the copy score was .53, which indicates both a significant ($p < .001$) relationship with the accuracy of the copy and that the score is measuring something else besides.

Both of Waber and Holmes's (1985, 1986) two other scores reflect aspects of strategy on the drawing task. An *Organization* score is based on five closely defined levels, each with a set of sublevels (e.g., at level II, left side of base rectangle aligned; at level IV, four sides of base rectangle aligned), all of which have to be met to reach a basal level. Additional points are awarded for each higher subgoal met by the drawing. A total of 13 points can be achieved. This scale proved to be very age sensitive, as 5-year-olds had a mean organization score of 1.72 + 1.08, while 14-year-olds' mean organization score was 9.51 + 3.93 (1986). This score correlated quite well ($r = .60$) with one using the Rey-Osterrieth system. While these are cumbersome, labor-intensive scoring techniques, the authors found them to be useful for identifying features characteristic of stages in children's developing abilities to copy the complex figure. A third, *Style,* score is based on the relative continuity or fragmentation of the main structural elements of the figure with cut-off scores to distinguish "part" constructions from "configural" ones.

A rather complicated system proposed by Bennett-Levy (1984a) scores a maximum of 18 points for *good continuation* with a point gained wherever a line is continued—either straight or angled—at one of 18 designated juncture points. A *symmetry* score measures the number of instances (out of 18) in which the symmetry of mirrored elements is preserved, with higher scores when natural components of a symmetrical element are drawn successively. Together these scores yield a *strategy total* score which is significantly related ($p < .001$) to the copy score and a strong predictor of later recall accuracy. Statistical analyses indicated that the good continuation and symmetry scores make independent contributions to the strategy total score.

R.S.H. Visser (1973) suggested that fragmented or piecemeal copies of the complex figure that are characteristic of patients with brain disease reflect their inability to process as much information at a time as do normal subjects. Thus, brain impaired persons tend to deal with smaller visual units, building the figure by accretion. Many ultimately produce a reasonably accurate reproduction in this manner, although the piecemeal approach increases the likelihood of size and relationship errors (Messerli et al., 1979).

The *Boston Qualitative Scoring System* (*BQSS*) is designed to assess qualitative aspects of Rey-Osterrieth copy and memory reproduction, and also executive aspects of reproducing the complex figure (R.A. Stern, Javorsky, et al., 1999; R.A. Stern, Singer, et al., 1994). The complex figure is divided into three hierarchically arranged elements (Configural Elements, Clusters, and Details) which are scored according to specific criteria. The BQSS yields 17 qualitative scores, most of which are assessed on a 5-point scale. Visuoconstruction skills are measured by scores such as Accuracy, Placement, Rotation, and Asymmetry. Executive function scales include Planning, Fragmentation, Neatness, and Perseveration, which correlate with traditional measures of executive functioning such as the Wisconsin Card Sorting Test, Trail Making Test Part B, and WAIS-R Similarities (Somerville et al., 2000). BQSS Summary scores are generated for *Planning, Fragmentation, Neatness, Perseveration,* and *Organization.* Because scoring using the *Comprehensive Scoring Guide* may be quite time-consuming (Boone, 2000), a shorter *Quick Scoring Guide* may be used instead.

An organizational scale developed for children, the *Rey Complex Figure Organizational Strategy Score* (*RCF-OSS*), appears suitable for adults as well (P. Anderson et al., 2001). It is a 7-point scale graded according to the level of organizational strategy (7 = excellent organization, 6 = conceptual organization, 5 = part-configural organization, 4 = piecemeal/fragmented organization, 3 = random organization, 2 = poor organization, 1 = unrecognizable or substitution). The focus is on how the rectangle and the vertical and horizontal midlines are rendered. In their normative sample of children ages 7 to 13, Anderson and his associates found that, surprisingly, older children used fragmented strategies more than younger ones.

Test characteristics. The mean Rey-Osterrieth copy scores for the five age groups reported by Delbecq-Dérouesné and Beauvois (1989) or by Spreen and Strauss (1998) do not differ greatly between age groups (see Table 14.7). Within an older range (from ages 65–93), copy scores do not decline significantly (see Mitrushina, Boone, and D'Elia, 1999), mostly showing about a 2-point drop from the late 60s to 80+. Fastenau, Denburg, and Hufford (1999) report that age explained 3% of the variance of their large adult sample. Ska, Dehaut, and Nespoulous (1987) compared younger (ages 40–50) and older (ages 60–82) subjects for the quality of their Rey-Osterrieth figure copies using the Waber-Holmes scoring system and found that older and younger subjects did not differ in their organizational approach as both groups tended to build the design by accretion, but small differences favoring the younger group's accuracy and overall organization were statistically significant. Men tend to get higher scores than women (Bennett-Levy, 1984a; Rosselli and Ardila, 1991). Left-handedness of the subject or in the subject's family, plus a mathematics or science academic major, distinguished women whose copies were most accurate from women who performed less well (C.S. Weinstein et al., 1990). Education also contributes a little to success on this test (Fastenau, Denburg, and Hufford, 1999; Rosselli and Ardila, 1991). The Fastenau group found that education accounted for 2% of their sample's variance. Scores achieved by healthy Portuguese adults with less than 10 years of education were 1 to 3 points below those with 10 or more years (Bonifácio, personal communication, July, 2003 [mdl]). Moreover, illiterates' scores ran one-third (younger subjects) to two-thirds (subjects over 56 years) below persons with 10+ years of education (Ardila, Rosselli, and Rosas, 1989).

Considering that the scoring criteria are not spelled out in exacting detail, interscorer reliability for the Rey figure tends to be surprisingly high—mostly above .95 (Bennett-Levy, 1984a; Carr and Lincoln, 1988; Rapport, Charter, et al., 1997), although Frazier and his colleagues (2001) found an interrater reliability coefficient of only .80, well below that for recall which, they suggested, was due to a ceiling effect attenuating the score range. Hubley and Tombaugh (1993) report an interrater reliability coefficient of .91 for the Taylor figure. A factor analytic study of a large battery placed the copy trial among tests requiring reasoning and planning (Baser and Ruff, 1987).

Neuropsychological findings. Messerli and his colleagues (1979) looked at copies of the Rey figure drawn by 32 patients whose lesions were entirely or predominantly localized within the frontal lobes. They found that, judged overall, 75% differed significantly from the model. The most frequent error (in 75% of the defective copies) was repetition of an element that had already been copied, an error resulting from the patient's losing track of what he or she had drawn where because of a disorganized approach. In one-third of the

TABLE 14.7 High and Low Mean Rey-Osterrieth Copy Scores from Two Studies with Five Age Groups Each

Study and Age Range	*High $\bar{X}$ Score: Age Group*		*Low $\bar{X}$ Score: Age Group*	
Delbecq-Derouesné and Beauvois: 20–65+	35.26 ± 1.8	26–40	33.90 ± 2.4	65+
Spreen and Strauss: 16–70+	35.53 ± 0.8	50–59	32.90 ± 2.7	70+

defective copies, a design element was transformed into a familiar representation (e.g., the circle with three dots was rendered as a face). Perseveration occurred less often, usually showing up as additional cross-hatches (scoring unit 12) or parallel lines (scoring unit 8). Omissions were also noted.

Laterality differences in drawing strategy emerge in several ways. L.M. Binder's (1982) study showed that patients with left hemisphere damage tend to break up the design into units that are smaller than normally perceived, while right hemisphere damage makes it more likely that elements will be omitted altogether. However, on CFT recall, patients with left hemisphere damage who may have copied the figure in a piecemeal manner tended to reproduce the basic rectangular outline and the structural elements as a configural whole, suggesting that their processing of all these data is slow but, given time, they ultimately reconstitute the data as a gestalt. This reconstitution is less likely to occur with right hemisphere damaged patients who, on recall, continue to construct poorly integrated figures. Patients with right hemisphere damage produced much less accurate copies than patients with left CVAs who, although on the whole less accurate than the normal control group, still showed some overlap in accuracy scores with the control group.

Pillon (1981a) observed that the complexity of the task tends to elicit evidence of left visuospatial inattention in patients with right-sided lesions; these patients may also pile up elements on the right side of the page resulting in a jumbled drawing (see Ducarne and Pillon, 1974). However, other stroke patients showed no overall differences between laterality groups in performance accuracy, although aphasic patients were less accurate than others with left brain lesions (L.M. Binder and Wonser, 1989). These differing findings are a good reminder that severity needs to be addressed as well as age, sex, etc. when matching patient groups. Moreover, since many patients with left hemisphere lesions use their nondominant hand to draw, the issue of motor skill must be taken into account when evaluating their CFT copies or generalizing from them.

Differences between patients with parieto-occipital lesions and patients with frontal lobe impairment were demonstrated in CFT copy failures (Pillon, 1981b). Errors made by the frontal patients reflected disturbances in their ability to program the approach to copying the figure. Patients with parieto-occipital lesions, on the other hand, had difficulty with the spatial organization of the figure. When given a plan to guide their approach to the copy task, the patients with frontal damage improved markedly. The patients with posterior lesions also improved their copies when provided spatial reference points. Use of spatial reference points did not improve the copies made by the patients with frontal damage, nor did those with parieto-occipital lesions benefit from a program plan. Lesion laterality did not differentiate candidates for temporal lobe resection for epilepsy (left TLE $M = 33.31 \pm 3.20$; right TLE $M = 33.27 \pm 3.01$) (Ogden-Epker and Cullum, 2001).

The effect of TBI on the ability to copy the complex figure can vary greatly: although almost half of the 43 TBI patients in Osterrieth's (1944) sample achieved copy scores of 32 or better, one-third of this group's scores were significantly low. Interindividual variability also showed up among mildly injured patients of whom 15% performed well below the normal score range (Raskin, Mateer, and Tweeten, 1998). Another sample of mild TBI patients achieved an average score of 32.3 which was significantly below the 34.4 ± 1.2 mean control group score and their 4.0 SD was considerably larger than those documented for normal subject groups (Leininger, Grammling, et al., 1990). For skewed distributions such as generated by the Rey copy trial, this group's average score tells only part of the accuracy story: the SD indicates a wide variability among patients with many having made quite poor copies.

Of patients with progressive dementia, Alzheimer patients generally do produce very defective copies, even when many ability test scores are still within the *average* range (Brouwers et al., 1984). Huntington's disease also greatly affects ability to copy the figures but not to the same degree as Alzheimer's disease (Brouwers et al., 1984; Fedio, Cox, et al., 1979). Abnormally low scores have also been documented for "high-functioning" Parkinson patients but with wide interindividual variability ($M = 23.38 \pm 6.44$) (Ogden, Growdon, and Corkin, 1990). Many of these subjects proceeded in a piecemeal manner, with only eight of 20 patients but 13 of 14 control subjects drawing the rectangle in one step or in consecutive steps. On completion of the test some of the patients "said that they had not perceived the rectangle at all when they were copying the drawing, but when it was pointed out to them they could see it clearly" (p. 132). In a controlled prospective study examining the neuropsychological effects of carotid endarterectomy, complex figure copy differentiated patients from lumbar spine surgical controls when tested on the first post-operative day and one month later (Heyer et al., 2002).

Organizational approach is related to recall in recently detoxified alcoholic patients as assessed both by Shorr's perceptual clustering index and by measures from the Boston Qualitative Scoring System (L.K. Dawson and Grant, 2000). Not surprisingly, poor organization at baseline was related to subsequent poor recall.

Miscellaneous Copying Tasks

Since any copying task can potentially produce meaningful results, examiners should feel free to improvise tasks as they see fit. Anyone can learn to reproduce a number of useful figures—either geometric shapes or real objects—and then draw them at bedside examinations or in interviews when test stimuli not available. Strub and Black (2000) and McCarthy and Warrington (1990, p. 79) give some excellent examples of how easily drawn material for copying—such as a cube, a Greek cross, and a house—can contribute to the evaluation of visuographic disabilities (e.g., see Fig. 14.8). The Mini-Mental State Examination (M.F. Folstein et al., 1975) incorporates copying two intersecting pentagons as a standard item. The battery for the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) includes four geometric figures of increasing difficulty—a circle, a diamond, intersecting rectangles, and a cube—to be copied as a measure of "constructional praxis." Normative data for white older adults (ages 50–89) who were enrolled in studies at 23 tertiary care medical centers have been published (K.A. Welsh, Butters, and Mohs, 1994), although these norms may not be applicable to African Americans or to less educated older adults seen in community practice settings (Fillenbaum, Heyman, Huber, et al., 2001).

Demographic factors such as age and education must be considered when interpreting performance on copying tasks (K.A. Welsh et al., 1994). On a copying task requiring copies of four geometric figures (circle, square, cube, and five-pointed star), the drawings of older subjects (ages 60–82) did not differ substantially from those made by two younger groups (ages 20–30 and 40–50), except that significantly fewer members of the older group (61%) than of the younger group (76.5%) copied the most difficult figure—the star—correctly (Ska, Désilets, and Nespoulous, 1986). However, when given drawings of four objects to copy (pipe, house with fence, little man, and detailed bicycle), the oldest group scored significantly lower than the other two age groups on all four items, achieving the lowest mean score on the most complex drawing—the bicycle.[1] Older subjects appeared to have particular difficulty organizing the spatial relationships of the different parts of the figures.

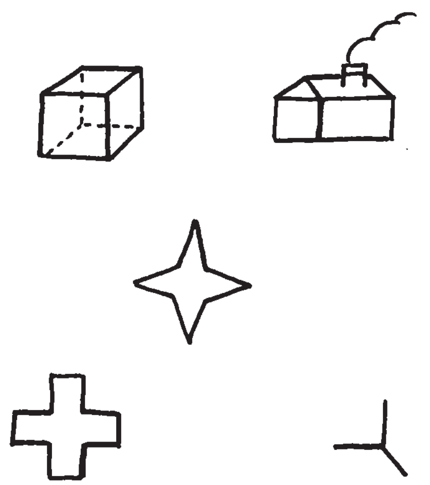


FIGURE 14.8 Sample freehand drawings for copying.

Copying tasks are also sensitive to brain impairment. Bilaterally symmetrical models for copying such as the cross and the star in Figure 14.8 or the top left and bottom designs from the Stanford-Binet Scale (Terman and Merrill, 1973, see Chapter 11, Fig. 11.2), are particularly suited to the detection of unilateral inattention. Alzheimer patients perform more poorly as a group than controls on the copying tests of the CERAD battery and these tests are also sensitive to changes in the Alzheimer group over the course of one year (J.C. Morris, Heyman, et al., 1989). While difficulties with drawing are typically apparent in only a subset of patients in the early stages of Alzheimer's disease, constructional impairments often become obvious as the disease progresses such that they may be markers of disease severity (Guérin, Ska, and Belleville, 1999). Clinical lore notwithstanding, copying tasks are not effective in discriminating patients with the frontal variant of frontotemporal dementia from Alzheimer patients (Grossi et al., 2002).

Copying Drawings (Carlesimo, Fadda, and Caltagirone, 1993)

Carlesimo and his colleagues developed an array of 15 line drawings, each of which is presented individually to the patient who is asked to copy them "as exactly as possible." Seven of the drawings in this test depict flat shapes (six geometric figures and one line drawing similar to a Stanford-Binet figure (upper left, Fig. 11.2, p. 455); five are flat drawings of objects, and three are items drawn in perspective (a box, a pyramid, and a house). Each drawing is rated on a 0–4 scale. The global copying score is the mean score across all 15 drawings. These authors report high interrater reliability among three judges using this scoring system ($r > .80$). Compared with scores of 27 demographically matched nonneurologic control subjects ($M = 2.7 \pm 0.4$), 29 patients who had sustained left hemisphere or 27 with right hemisphere strokes (mostly ischemic) did signifi-

[1]Scoring systems for these eight drawings appear in an appendix to the article. Bicycle scoring follows the guidelines given below (p. 552).

cantly worse on this test, although not differently from each other ($M_L = 2.2 \pm 0.7$, $M_R = 2.2 \pm 0.5$). Using a cut-off of 2 SD below the mean for control subjects, 34.4% of the left hemisphere stroke group and 29.6% of the right hemisphere stroke group were impaired on this test. This is consistent with reports by previous investigators (e.g., Arena and Gainotti, 1978).

Different factors influenced the performance of the patient and control groups on the Copying Drawings test. For controls and patients with left hemisphere lesions who were able to copy with their right hands, constructional test performance was strongly correlated with performance on *Figure Matching* (a multiple-choice version of 10 of the items from Copying Drawings designed to assess visual perception). In contrast, motor skill (Finger Tapping speed) was the factor most strongly associated with the constructional test scores of left hemisphere lesioned patients who had to use their left hands due severe motor deficits. The drawing scores of patients with right hemisphere lesions were most strongly correlated with "manipulospatial ability" (e.g., *Visual Tracking,* drawing a line through a track composed of two parallel black lines).

Developmental Test of Visual-Motor Integration (VMI) (Beery and Buktenica, 1997)

When it is useful to evaluate test performances in terms of developmental levels, this test will provide age norms from ages 3 to 18 for accuracy in copying a set of 24 geometric figures arranged in order of developmental sequence, from less to more complex. Since development of copying accuracy levels off in the middle teen years, these norms are applicable to adults, at least into the seventh decade. The items in the fourth edition are identical to those in the third, but two supplemental standardized tests of visual perception and motor coordination, using the same stimuli, are added to the fourth edition. Some of these figures will be familiar to many examiners, such as the circle with the 45° rotated square and the overlapping hexagons of the Bender-Gestalt (Fig. 14.1, p. 533), the "tapered box" of the Stanford-Binet and Wechsler Memory Scale (Fig. 11.2, p. 455, upper right), and of course, the cube. The third and fourth editions differ in their scoring systems—especially at the older levels—and the fourth edition has expanded norms, although the absolute mean difference in scores obtained on the two editions is small (S.D. Mayes and Calhoun, 1998).

Free Drawing

The absence of a model changes the perceptual component of drawing from the immediate act of visual perception involved in copying a geometric design or object to the use of mental imagery to create a perceptual construct, a "picture in the mind," in response to an instruction to draw a particular shape or object. This difference may account for the failure of Warrington, James, and Kinsbourne (1966) to find a systematic way to sort freehand drawings on the basis of the side of the lesion, despite the many clear-cut differences between the drawings of patients with right and left hemisphere involvement. Yet some differences do persist, such as a greater likelihood of left-sided visual inattention, an increased tendency to sketch over drawings, and more details—both relevant and inconsequential—among patients with right hemisphere lesions; drawings of left hemisphere patients are more likely to have fewer details, giving the drawings an "empty" or poorly defined appearance (McFie and Zangwill, 1960). The presence of these lateralizing characteristics may enable the examiner to identify some cognitively impaired patients on the basis of their free drawings. Specific aspects of the visuographic disability may be studied by means of different drawing tasks (e.g., see also Drawing and Copying Tests for Inattention, Chapter 10, pp. 385–386). For example, the ability to draw human figures may be dissociated from other types of drawing, as in patients with Williams syndrome, whose ability to copy geometric figures (e.g., Beery and Buktenica's VMI) is deficient yet their ability to draw human figures is preserved (Dykens et al., 2001).

Human figure

Considering the number of times either the Draw-a-Person test or the House–Tree–Person test was mentioned in a recent survey on test use (Camara et al., 2000), tests involving human figure drawing come close to personality inventories in the frequency with which they are used by clinical psychologists but rank low in frequency of use by neuropsychologists. This is not surprising since human figure drawing has long been a staple in personality assessment, as well as a popular technique for evaluating children's mental ability. Among the virtues of the human figure drawing test are its simplicity of administration, requiring only pencils, paper, and the instruction to draw a person; its relative speed of administration, for few patients take more than five minutes to complete a drawing; and its applicability to all but those patients with such severe disabilities that they cannot draw.

The quality and complexity of children's drawings increase with age at a sufficiently regular pace to warrant the inclusion of drawing tests in the standard repertory of tests of cognitive development (Barrett and Eames, 1996; Fredrickson, 1985). These human figure drawing tests have been particularly prized for measuring the cognitive potential of or specific performance patterns of developmentally disabled or neurologically impaired children. Human figure drawing tests have also been used as brief cognitive screening procedures with young children.

Machover (1948) and Buck (1948) developed the best-known systems for appraising personality on the basis of human figure drawings. Both of these systems attend to dimensions and characteristics of the drawings that are, for the most part, irrelevant to neuropsychological questions. In the United States, the Goodenough "Draw a Man" test and its revision utilizing drawings of a man and a woman have provided the most popular system for estimating developmental level from human figure drawings (D.B. Harris, 1963). The subject can achieve a maximum score of 73 (man) and 71 (woman) on the Harris-Goodenough scale, which has also been modified for use with elderly subjects (Clément et al., 1996; Ericsson, Hillerås, et al., 1994).

This untimed test begins with verbal instructions to produce the desired drawing—a man or a woman, or both. The upper age norms end at 15, reflecting the normal leveling off of scores on drawing tests in the early teens. Age 15 drawing norms are applicable to adult patients. When used as a projective technique, subjects are instructed to "draw a person," leaving it up to them to determine the sex of their figure.

Test characteristics. Interscorer reliability coefficients for the Harris-Goodenough scoring system have been reported in the .80 to .96 range in children (L.H. Scott, 1981) and .89 to .96 in older adults (Clément et al., 1996; Ericsson, Hillerås, et al., 1994). Test–retest reliability is in the .61 to .91 range for children (Franzen, 1989).

The quality of human figure drawings diminishes with age, even among healthy adults (Ska, Désilets, and Nespoulous, 1986). An analysis of these drawings on the basis of the presence or absence of 26 elements (e.g., ears, clothing), and of their organization (28 items; e.g., attachment, articulation, dimensions, symmetry of limbs) suggested that organizational quality declines more rapidly than the number of elements.

Neuropsychological findings. Descriptions of human figures drawn by cognitively impaired patients with either specific visuographic disturbances or conditions of more generalized cognitive debilitation usually include such words as *childlike, simplistic, not closed, incomplete, crude,* and *unintegrated.* Several features of human figure drawings have been associated with brain impairment: lack of detail; loosely joined or noticeably shifted body parts; shortened and thin arms and legs; disproportionate size and shape of other body parts (other than the head); petal-like or scribbled fingers; and perseverative loops (Ericsson, Winblad, and Nilsson, 2001; Reznikoff and Tomblen, 1956). As on any drawing task, patients with left hemisphere lesions tend to favor the upper left portion of the page while those with right-sided lesions show a slight drift to the right side of the page (Gasparrini et al., 1980). However none of these is sufficiently pathognomonic to be diagnostic of cognitive impairment.

In evaluating human figures drawn by cognitively impaired patients, the impact of their emotional status should not be overlooked. This is particularly true for mildly impaired patients, whose sensitivity to their loss has precipitated a highly anxious or depressed mood that may lower the quality of their drawings or exaggerate the extent of their drawing impairment.

Bicycle

Most of the noncontent characteristics of the human figure drawings of cognitively impaired patients apply to other free drawings, too. Bicycle drawing can serve as a test of mechanical reasoning as well as of visuographic functioning (from Piaget, 1930, described in E.M. Taylor, 1959). The instructions are simply, "Draw a bicycle." The material consists of letter-size paper and pencils. When the drawing is completed, the examiner who is interested in ascertaining whether the patient can think through the sequential operation of a bicycle can ask, "How does it work?" This question should always be asked when the submitted drawing is incomplete. Mildly confused, distractible, and structure-dependent patients and those whose capacity for planning and organization is compromised often produce drawings lacking a necessary element—such as pedals, drive chain, or seat. They will usually note it when questioned and repair the omission. some refer to the missing component but remain satisfied with the incomplete drawing, or may overlook the missing part but add an inconsequential detail or superficial embellishments (see Figs. 3.15a,b and 6.2, pp. 69, 141). To retain the original incomplete drawing while still giving patients an opportunity to improve their performance, we [dbh, mdl] recommend handing patients a colored pen or pencil if they wish to make additions or corrections after indicating that they were done. In this way, the original omission(s) are preserved.

In order to quantify the bicycle drawing task, a 20-point scoring system was devised (Table 14.8, p. 552). Lebrun and Hoops (1974) described a 29-point scoring system devised by Van Dongen to investigate the drawing behavior of aphasic patients. This latter system

TABLE 14.8 Scoring System for Bicycle Drawings

Score 1 point for each of the following:

1. Two wheels
2. Spokes on wheels
3. Wheels approximately same size (smaller wheel must be at least three-fifths the size of the larger one)
4. Wheel size in proportion to bike
5. Front wheel shaft connected to handlebars
6. Rear wheel shaft connected to seat or seat shaft
7. Handlebars
8. Seat
9. Pedals connected to frame at rear
10. Pedals connected to frame at front
11. Seat in workable relation to pedals (not too far ahead or behind)
12. Two pedals (one-half point for one pedal)
13. Pedals properly placed relative to turning mechanism or gears
14. Gears indicated (i.e., chain wheel and sprocket; one-half point if only one present)
15. Top supporting bar properly placed
16. Drive chain
17. Drive chain properly attached
18. Two fenders (one-half point for one fender; when handlebars point down, always give credit for both fenders)
19. Lines properly connected
20. No transparencies

TABLE 14.9 Bicycle Drawing Means and Standard Deviations for 141 Blue Collar Workers in Five Age Groups

Age Group	*Number*	*Mean*	*SD*
20–24	21	13.95	4.03
25–34	46	13.78	3.55
35–44	37	14.22	3.63
45–54	27	12.59	3.65
55–64	10	13.90	5.51

Adapted from Nichols (1980)

includes scoring for many details (such as the tires, the taillight, or crossbars on a parcel carrier) that are infrequently drawn by normal subjects and rarely, if ever, drawn by brain damaged patients. Greenberg and colleagues (1994) recommend a 26-item scoring system organized into four categories: *Parts/Complexity* (7 items; e.g. two wheels, complete frame), *Motor Control* (5 items: e.g., pencil control, lines meet target destination), *Spatial Relationships* (9 items; e.g., placement of parts, size consistency), *Mechanical Reasoning* (five items; e.g., chain connection, steering possibility).

Test characteristics. Using the scoring system given in Table 14.8, Nichols (1980) found no pattern of age decline for five age ranges from 20–24 to 55–64 (see Table 14.9). However Ska and her colleagues (1986), using the same 20-item scoring system, did observe a decline in the quality of bicycle drawings with age, most notably between the older age groups of 40–50 and 60–82. This showed up prominently in omission of parts, although organization of the bicycle (e.g., wheel dimensions, pedals attached) showed an even steeper decline with age than loss of elements. The items most frequently left out by the older group were the front wheel shaft and the gears (each 67%), the rear wheel shaft (72%), the drive chain (78%), and the frame bars (80%). Nichols (1980) reported an interrater reliability coefficient of .97, with least agreement on items 3, 4, 6, 10, and 20 (see Table 14.8). Retesting three to five weeks after the initial examination produced a reliability coefficient of .53 with significant practice effects ($p < .003$).

Hubley and Hamilton (2002), evaluated the Greenberg scoring system on 22 men and 28 women, ages 21–80 and an education span from 10 to 21 years. They reported relatively small correlations with age (.14 to .28), with a sex difference only on Mechanical Reasoning ($p < .01$). Test–retest reliabilities for each category (.52 to .79) were satisfactory; only the Mechanical Reasoning score increased significantly on retest. Highest correlations were with Block Design (.28 to .47) and the Complex Figure (R-O, .30 to .48).

Neuropsychological findings. Comparing the accuracy of drawings of a cube, a house, and a bicycle, Messerli and his colleagues (1979) found that 56% of patients with frontal damage failed to draw an adequate bicycle, either due to a generally impoverished rendition or to poor organization, although spatial relationships overall were not likely to be distorted. Failures due to poor organization distinguished patients with frontal lesions (82% of whom demonstrated poor organization) from a group with nonfrontal lesions (25%). Frontal patients tended to draw without an apparent plan and without focusing first on the bicycle's structure before drawing details.

The bicycle drawing task may also bring out the drawing distortions characteristic of lateralized involvement. Patients with right hemisphere lesions tend to reproduce many of the component parts of the machine, sometimes with much elaboration and care, but misplace them in relation to one another, whereas left hemisphere patients are more likely to preserve the overall proportions but simplify the elements of the bicycle (Lebrun and Hoops, 1974; McFie and Zangwill, 1960). Severely impaired patients, regardless of the site of the lesion, perform this task with great difficulty, producing incomplete and simplistic drawings. In our experience, patients suffering from judgmental impairment, defective planning, difficulty with conceptual integration or accurate self-appraisal, inadequate self-monitoring, and/or impulsivity will often omit a crucial part of the bicycle's mechanism—either the drive chain or the pedals, or both.

House

This is another popular—and useful—drawing test. When giving it, the examiner asks subjects to "draw the best house you can" and specifies that it should show two sides of the house. A simple and logical scoring system is available which has demonstrated sensitivity to aging effects (Ska, Désilets, and Nespoulous, 1986, see Table 14.10). As with other items, when compared with younger subjects, older persons tend to include fewer elements and integrate them less well (Ska, Martin, and Nespoulous, 1988).

Messerli and his colleagues (1979) reported that while only 24% of patients with frontal lobe damage were unable to draw a reasonable appearing house, these failures typically represented an inability to work from structure to detail. House drawings may elicit difficulties in handling perspective that are common among cognitively deteriorated patients. An alert and otherwise bright patient who struggles with a roofline or who flattens the corner between the front and side of the house is more likely to have right hemisphere damage than left hemisphere involvement.

TABLE 14.10 Scoring System for House Drawing

Score 1 point for each of the following:

1. One side (square or rectangular)
2. A second side
3. Perspective (each side on a different plane; the angled side must differ by more than 5° from base of the house)
4. A roof
5. Roof placed correctly on the house (with respect to the orientation of the sides)
6. Door
7. Window(s)
8. Chimney
9. Adjacent features (fence, road, steps to the door)
10. Elements connected well (no more than one excess line, no more than two lines not joined or extending beyond their connecting points)
11. Appropriate proportions (wider than tall, fence reasonably oriented)
12. No incongruities (e.g., transparencies, door "in the air," house "suspended" as if on incompletely constructed pilings

Adapted from Ska, Desilets, and Nespoulous (1986)

Clock face

Clock face drawings were originally used to expose unilateral visuospatial inattention thought to be associated with right parietal dysfunction (Battersby et al., 1956). M. Freedman, Leach, and their collaborators (1994) pointed out that clock drawing is in fact a complex task that is sensitive to a variety of focal lesions, tapping not only visuoperceptual and visuospatial abilities, but also receptive language, numerical knowledge, working memory, and executive functions (both motor and cognitive). It has come to be widely used in geriatric practice and memory disorders clinics, where it is valued for its ability to provide a quick "cognitive scan" and to demonstrate a patient's difficulties to family members.

The first systematic use of the clock test was in the *Parietal Lobe Battery,* which included both drawing a clock to command and setting clock hands (Borod, Goodglass, and Kaplan, 1980; Goodglass and Kaplan, 1983). Clock drawing to command was incorporated into the Praxis subscale of the Cambridge Cognitive Examination shortly thereafter. On *clock drawing* to command, the patient is instructed to "Draw the face of a clock showing the number and two hands, set to 10 after 11," which gives additional information about the patient's time orientation and capacity to process numbers and number–time relationships. Clock drawings are rated for accuracy of the circular shape, accuracy of numbers, and symmetry of number placement, with scores ranging from 0 to 3. For *clock setting* in the Parietal Lobe Battery, the patient is shown a sheet of paper with four blank clock faces, each of which has dashes marking the positions of the 12 numbers and is asked to draw in the two hands of the clock to make the faces read 1:00, 3:00, 9:15, and 7:30. Each clock is rated for the correct placement and relative lengths of the hands, with a total of 12 points possible.

Over a dozen administration and scoring systems have been published, a number of which are summarized in Table 14.11, p. 554. Many of these—as well as some other less commonly used systems are described in Shulman (2000). Some systems present the subject with a blank page (Goodglass and Kaplan, 1983b; see also Goodglass, Kaplan, and Barresi, 2000), whereas others present a sheet with an empty circle. The methods also differ regarding what time(s) should be set. Although "10 minutes past 11" is the most widely favored—no doubt because of its ability to elicit

TABLE 14.11 Commonly Used Quantitative Scoring Systems for Clock Drawing

Method	*Test Conditions*	*Scoring*	*Suggested Cut-off for Impairment*	*Interrater Reliability**
Shulman, Shedletsky, & Silver, 1986; Shulman, Gold et al., 1993	Predrawn circle ("Set hands to 10 past 11")	5-point global rating (5 = perfect to 0 = no resemblance to a clock)	<4	.83–.93
T. Sunderland, Hill, et al., 1989	Blank page ("Draw clock and set hands to 2:45")	10-point ordinal rating scale (1–5 cover clock face and number placement and 6–10 cover hand drawing and placement)	<6	.82–.92
Wolf-Klein et al., 1989	Predrawn circle ("Put the numbers on the clock")	10-point rating scale (comparing number placement with examples)	<7	.81–.93
Spreen & Strauss, 1991, 1998	Blank page ("Draw face of a clock with the numbers; draw hands pointing at 20 to 4")	10-point rating scale, adapted from Sunderland and Wolf-Klein scales	<7	NA
Mendez, Ala, & Underwood, 1992	Blank page ("Draw clock and set hands to 10 past 11")	20-point scale (12 for numbering, 5 for hand placement, and 3 for general impression)	<18	.92–.97
Rouleau et al., 1992	Blank page ("Draw clock and set hands to 10 after 11"); clock copy	10-point scale (2 points for clock face, 4 points each for number and hand placement); also 6-item qualitative error analysis	NA	.95–.96
Tuokko, Hadjistavropoulos, et al., 1992, 1995	Predrawn circle ("Set hands to 10 past 11"); 5 clock setting and 5 clock reading items	Presence/absence or count of 25 errors, categorized into 7 subscales; 0–3 points for each clock setting and reading	>2 errors on clock drawing	.99
Y.I. Watson et al., 1993	Predrawn circle ("Draw in the numbers")	7-point rating of number placement in each of 4 quadrants (0 = least to 7 = most impaired)	>3	.81–.98
M. Freedman, Leach, et al., 1994	Free drawing ("Draw block and set to 6:45"); also clock analysis (6:05) and 3 clock readings	15-point cumulative score on "critical items" done accurately by normal subjects; extensive normative data	NA	.98
Manos & Wu, 1994	Predrawn clock ("Set clock to 10 minutes after 11")	10-point rating, with 8 points for correct number placement and 2 for correct hand placement	<8	.94
Royall, Cordes, & Polk, 1998	Blank page ("Draw me a clock that says 1:45"); clock copy	15-point rating for each part (CLOX1, free drawing, and CLOX2, copying)	<10 (CLOX1) <12 (CLOX2)	.93–.94

*Reliability coefficients are derived from several comparative studies, including Suhr, Grace, Allen, et al. (1998), $n = 71$ community-based elderly and 101 stroke patients; Tuokko, Hadjistavropoulos, Rae, & O'Rourke (2000), $n = 493$ subjects from the Canadian Study of Health and Aging; Storey et al. (2001), $n = 127$ consecutive referrals to a geriatric medical outpatient clinic; and Schramm et al. (2002), $n = 123$ consecutive referrals to a memory disorder clinic (79 of whom were diagnosed with varied dementias).

stimulus-bound errors to the number 10—exactly what instructions are given regarding the clock hands doesn't seem to matter as all instructions elicit discriminable and neuropsychologically meaningful responses. However, including instructions to show the hands indicating a specified time can add greatly to understanding deficits—or demonstrating competencies. Edith Kaplan (1988) recommended including both drawing to command and copy trials, citing examples of failure on one form of this test and success on the other. Several investigators have heeded this suggestion and made both drawing to command and copying explicit components of their clock drawing procedures (Rouleau et al., 1992; Royall, Cordes, and Pok, 1998; Tuokko, Hadjistavropoulos, et al., 1992).

The different methods for scoring clock drawing vary substantially in their emphases and complexity. Some scoring methods rely primarily or exclusively on the accuracy of numbers and their placement, with little or no attention to the clock hands (Manos and Wu, 1994; Y.I. Watson et al., 1993; Wolf-Klein et al., 1989). Other methods provide a detailed system for analyzing errors in clock drawing (Rouleau et al., 1992; Tuokko, Hadjistavropoulos, Miller, and Beattie, 1992). Examiners interested in using the clock drawing test will want to attend to these nuances of administration and scoring to select the clock drawing method best suited to their testing situation.

Test characteristics. The psychometric properties of several of the clock drawing scoring systems have been compared in several large-scale studies (Schramm et al., 2002; Storey et al., 2001; Tuokko, Hadjistavropoulos, et al., 2000). Interrater reliability coefficients are uniformly high, irrespective of the scoring system used or the population to which it is applied (see Table 14.11, p. 554). Most scoring systems are in fact highly intercorrelated: e.g., coefficients ranging from 0.73 (Shulman's, 2000, method with Royall CLOX1) to .95 (Mendez, Ala, and Underwood's 1992 method with Royall CLOX1) in one study (Royall, Mulroy, et al., 1999). An evaluation of interscorer reliability for three systems also found high correlations, many above .91; most low interscorer agreements were on scores for "overall contour of the clock face" (South et al., 2001).

The ability to draw a clock face with reasonably good accuracy changes little over the years in cognitively intact community-dwelling elderly adults, even in those well into their 90s (M. S. Albert, Wolfe, and Lafleche, 1990; Cahn and Kaplan, 1997). This may not be the case for less educated adults, particularly those with fewer than 10 years of education, whose clock drawing ability appears to decline starting in the mid-70s (La Rue, Romero, et al., 1999; Marcopulos, McLain, and Giuliano, 1997). Education clearly has an impact on clock drawing performance and must be taken into account in interpreting results on this test (Ainslie and Murden, 1993). Clock drawing test performance is moderately correlated not only with other measures of visuoconstruction (Block Design $r = .42$) but also with several other cognitive functions, including receptive language (Token Test, $r = .54$), semantic (animal) fluency ($r = .44$), and aspects of executive function (Mattis Dementia Rating Scale, Initiation–Perseveration scale, $r = .44$). They appear to be unrelated to memory (Cahn-Weiner et al., 1999; Suhr, Grace, et al., 1998).

Neuropsychological findings. Quantitative scores from the varied clock drawing systems are often less helpful in identifying lesion location (e.g., right vs. left, anterior vs. posterior, or cortical vs. subcortical) in patients with focal lesions than are qualitative analyses of their error patterns (Suhr, Grace, et al., 1998). For example, patients with right anterior lesions often have difficulty managing the simultaneous demands of the clock drawing task (M. Freedman, Leach, et al., 1994). Patients with right posterior lesions typically show spatial inattention—leaving out numbers from the left side of the clock face, or when they do include all the numbers, spatial disorganization—bunching most of the numbers along the right margin of the clock's outline, or struggling to round out the left side of the clock (M. Freedman, Leach, et al., 1994; Suhr, Grace, et al., 1998). Patients with right parietal lesions may be more prone to distort or neglect the lower left quadrant of the clock face, whereas those whose lesions are predominantly right temporal are more likely to have difficulty with the upper left quadrant (e.g., see E. Kaplan, 1988). A few patients, all but one of whom sustained a right hemisphere stroke, have actually written numbers counterclockwise around the clock face, although this was transient (D.S. Jones, 2000; Kumral and Evayapan, 2000).

Patients with left-sided—particularly anterior—lesions may be inattentive to the right side of the clock face (Ogden, 1985a,b). They may also have difficulties with the sequencing demands of the task and are prone to perseverative errors (M.L. Albert and Sandson, 1986; M. Freedman, Leach, et al., 1994). In contrast, the errors of patients with left posterior lesions often stem from poor task comprehension and agraphia.

Patients with Alzheimer's disease consistently do much worse than healthy controls on clock drawing tests (Cahn-Weiner et al., 1999). Performance on the free drawing (CLOX1) component of Royall's clock drawing procedure can predict level of independence (independent vs. assisted living vs. skilled nursing) among residents of a comprehensive care retirement community (Royall, Chiodo, and Polk, 2000). Assumptions about the evolution of constructional impairments—namely, that clock hands and time setting are affected first, followed by number placement and shape of the clock face (T. Sunderland, Hill, et al., 1989)—have been criticized (Rouleau et al., 1992). Forstl and colleagues (1993) found that clock drawing performance was directly related to counts of large neurons in the hippocampus and in the parahippocampal gyrus but not the parietal lobe. In an MRI study, Cahn-Weiner and her colleagues (1999) reported that clock drawing performance was moderately correlated with gray matter volumes in the right anterior-superior temporal lobe but not the parietal lobe or other brain regions.

The sensitivity of clock drawing to Alzheimer's disease is sufficiently great that it is often recommended as a screening procedure, either alone or as a supplement to the Mini-Mental State Examination (Shulman, 2000). Sensitivity and specificity values will vary somewhat depending on the scoring method used and the composition of the sample. The Mendez, Shulman, and Tuokko methods appear to be the most sensitive but least specific in screening for dementia, whereas the Watson and Wolf-Klein methods are specific but relatively insensitive (Brodaty and Moore, 1997; Schramm et al., 2002; Storey et al., 2001; Tuokko, Hadjistavropoulos, et al., 2000). Interestingly the Watson and Wolf-Klein methods are the only two that do not ask examinees to place the hands on the clock. Specific error patterns on clock drawing, such as accuracy in hand drawing and placement or substitutions, may also be useful in detecting patients in the early stages of Alzheimer's disease (Cahn, Salmon, et al., 1996; Esteban-Santillan et al., 1998; O'Rourke et al., 1997) and in distinguishing early Alzheimer patients from patients who are depressed (N. Herrmann et al., 1998).

Clock drawing performance may be able to differentiate patients with Alzheimer disease from those with other forms of dementia, such as vascular dementia or frontotemporal dementia (Heinik et al., 2002; Moretti et al., 2002b). In one study vascular dementia patients were twice as likely as Alzheimer patients to adopt a segmentation strategy (i.e., using radial lines to divide the circle into segments before drawing in the numbers and the hands) (D. Meier, 1995). In another study vascular dementia patients were distinguishable from those with Alzheimer's disease because their clock drawing performance did not improve when they were allowed to copy a clock as opposed to drawing it to command (Libon, Swenson, et al., 1993; Libon, Malamut, et al., 1996). Rouleau and her colleagues (1992) made a similar observation regarding the tendency for the clock drawing performance of Alzheimer patients to improve during the copy conditions, whereas that of Huntington patients did not. Although both patient groups made visuospatial errors, graphomotor planning problems were exhibited almost exclusively by patients with Huntington's disease, whereas conceptual errors—reflecting the erosion of knowledge about the attributes, features, and meaning of a clock—were observed primarily in the drawings of patients with Alzheimer disease. Failure to draw the hands or the numbers were some of the most common conceptual errors observed. Conceptual errors were predictive of more rapid deterioration over the subsequent two years (Rouleau et al., 1996).

ASSEMBLING AND BUILDING

More than any other kind of test, assembling and building tasks involve the spatial component in perception, at the conceptual level, and in motor execution. Inclusion of both assembling and drawing tests in the battery will help the examiner discriminate between the spatial and the visual aspects of a constructional disability and estimate the relative contributions of each.

With Block Design and Object Assembly, the Wechsler tests contribute two of the basic kinds of construction tasks to the neuropsychological examination, both involving two-dimensional space. Three-dimensional construction tasks call upon a somewhat different set of functions, as demonstrated by patients who can put together either the two- or the three-dimensional constructions, but not both (Benton and Fogel, 1962). Other construction tasks test the ability to execute reversals in space and to copy and reason about different kinds of visuospatial maneuvers.

Two-Dimensional Construction

Block Design (Wechsler, 1955, 1981, 1997a)

On this construction test, the subject is presented with red and white blocks: two, four, or nine, depending on the item. Each block has two white and two red sides, and two half-red half-white sides with the colors divided along the diagonal. The subject's task is to use the blocks to construct replicas of the easy block constructions made by the examiner and then designs of increasing difficulty printed in a scale smaller than the blocks (see Fig. 14.9, p. 557). The designs in the WAIS-III Block Design stimulus booklet are larger than in earlier versions, a welcome improvement for testing examinees with visual acuity problems. The WAIS-III expands the difficulty range of the Block Design test by adding five new designs to the nine WAIS-R designs: one difficult design is added at the end, and four easier designs are included at the beginning. An experienced examiner can administer the WAIS-III Block Design test in slightly over ten minutes (Axelrod, 2001). Detailed instructions are given in the test manual.

Of the 10 items above the *defective* level (<−2 SD) on WAIS-III (Designs 5–14), Designs 5 and 8 of the four-block designs and Design 10 (the first nine-block design) are relatively easier because they contain implicit grid information, as do the first four designs. When patients with visuospatial disorders, develop-

FIGURE 14.9 Block Design test. (Reproduced by permission of The Psychological Corporation)

mentally delayed individuals, or careless persons fail one of these items, it is more likely to be due to incorrect orientation of the diagonal of a red-and-white block than to errors in laying out the overall pattern. In contrast, the diagonal patterns of the other designs reach across two- and three-block spans. Concrete-minded persons and patients (particularly those with right hemisphere damage) with visuospatial deficits have particular difficulty constructing these diagonal patterns (see also Walsh and Darby, 1999).

Impaired persons sometimes do not comprehend the Block Design task when given the standard instructions alone. An accompanying verbal explanation like the following may help to clarify the demonstration:

The lower left-hand (patient's left) corner is all red, so I put an all red block here. The lower right-hand corner is also all red, so I put another all red block there. Above it in the upper right corner goes what I call a "half-and-half" block (red and white halves divided along the diagonal); the red runs along the top and inside so I'll put it above the right-hand red block this way (emphasizing the angulation of the diagonal), etc. [mdl].

Non-standard administrations of Block Design. There may be circumstances in which the examiner wishes to give the patient an opportunity to solve problems that were failed under standard conditions, or to bring out different aspects of the patient's approach to the Block Design problems. For example, following completion of the Block Design test, the examiner can return to any design that was puzzling or that elicited an atypical solution and ask subjects to try again. The examiner can then test for the nature of the difficulty by having them verbalize as they work, by breaking up the design and constructing and reconstructing it in small sections to see if simplification and practice help, or by giving a completed block design to copy instead of the smaller and unlined printed design. The examiner can test for perceptual accuracy alone by asking subjects to identify correct and incorrect block reproductions of the designs (Bortner and Birch, 1962).

The examiner who wants to know whether slow or initially confused patients can copy a design that is incomplete when the time limit is reached may choose to allow them to continue working [mdl]. When the examiner times discreetly, patients remain unaware that they have overrun the time so that if they complete the design correctly, they will have the full satisfaction of success. As on other timed tests, it is useful to obtain two scores when patients fail an item because they exceeded the time limit. Usually, permitting patients to complete the design correctly means waiting no more than an extra minute beyond the allotted time. With very slow patients, the examiner has to decide whether waiting the five or seven minutes they may take to work at a problem is time well spent in observation or providing an opportunity for success, whether the patients' struggles to do a difficult or perhaps impossible task distress them excessively, or whether they need the extra time to succeed at this kind of task at all. It is usually worthwhile to wait out very slow patients on at least one design to see them work through a difficult problem from start to finish and to gauge their persistence. However, when patients are obviously in over their depth and either do not appreciate this or refuse to admit defeat, the examiner needs to intervene tactfully before the task so upsets or fatigues them that they become reluctant to continue taking any kind of test.

The WAIS-R NI administration of Block Design called for subjects to be given 12 rather than nine blocks, making it easier for patients who did not readily conceptualize the squared 2×2 or 3×3 format to give a distorted response that demonstrates this deficiency (E. Kaplan, Fein, et al., 1991). Follow-up trials were then given for failed items, using block models drawn with a superimposed grid to see whether this level of structuring improved the patient's performance.

Qualitative aspects of Block Design performance. Block Design lends itself well to qualitative evaluation. The manner in which patients work at Block Design can reveal a great deal about their thinking processes, work habits, temperament, and attitudes toward themselves. The ease and rapidity with which patients relate the individual block sides to the design pattern give some indication of their level of visuospatial conceptualization. At the highest level is the patient who comprehends the design problem at a glance (forms a "gestalt" or unified concept) and scarcely looks at it again while putting the blocks together rapidly and correctly. Patients taking a little longer to study the design, who perhaps try out a block or two before proceeding without further hesitancy, or who refer back to the design continually as they work, function at the next lower level of conceptualization. Trial and error approaches contrast with the "gestalt" performance. In these, subjects work from block to block, trying out and comparing the positioning of each block with the design before proceeding to the next one. This kind of performance is typical of persons in the *average* ability range. These individuals may never perceive the design as a total configuration, nor even appreciate the squared format, but by virtue of accurate perception and orderly work habits, many can solve even the most difficult of the design problems. Most people of *average* or better ability do form immediate gestalts of at least five of the easiest designs and then automatically shift to a trial and error approach at the point that the complexity of the design surpasses their conceptual level. Thus, an informal indicator of ability level on this task is the most difficult design that the subject grasps immediately.

Patients' problem-solving techniques reflect their work habits when their visuospatial abilities are not severely compromised. Orderliness and planning are among the characteristics of working behavior that the block-manipulating format makes manifest. Most examinees work systematically in the same direction—from left to right and up to down, for example—whereas others tackle whatever part of the design meets their eye and continue in helter-skelter fashion. Most examinees quickly appreciate that each block is identical, but some turn around each new block they pick up, looking for the desired side, and if it does not turn up at first they will set that block aside for another one. Some work so hastily that they misposition blocks and overlook errors through carelessness, whereas others may be slow but so methodical that they never waste a movement. Ability to perceive errors and willingness to correct them are also important aspects of work habits that can be readily seen on Block Design. Temperamental characteristics, such as cautiousness, carefulness, impulsivity, impatience, apathy, etc., appear in the manner in which patients respond to the problems. Self-deprecatory or self-congratulatory statements, requests for help, rejection of the task, and the like betray their feelings about themselves.

Examiners should record significant remarks, as well as kinds of errors (e.g., placement or position errors, rotation errors, and broken configuration) and manner of solution (e.g., location of blocks as they are placed and which blocks are correctly positioned). Most items elicit only one type of single-block error, either errors of placement or position (Joy et al., 2001). Broken configuration errors are not as rare as originally thought: slightly over one-third of the older adults in this study's sample produced one or more broken configurations on WAIS-R Block Design, mostly only one.

For quick, successful solutions, examiners usually need to note just whether the approach was conceptual or trial and error, and if trial and error, whether it was methodical or random. Time taken to solve a design will often indicate the patient's conceptual level and working efficiency since "gestalt" solutions generally take less time than those solved by methodical trial and error, which in turn are generally quicker than random trial and error solutions. It thus makes sense that high scores on this test depend to a considerable extent on speed, especially for younger subjects. Examiners can document patient difficulties such as false starts and incorrect solutions by sketching them on the blank grids in the Incorrect Designs section of the Record Form. Of particular value in understanding and describing the patient's performance, however, are sequential sketches of the evolution of a correct solution from initial errors, or of the compounding of errors and snowballing confusion of an ultimately failed design (e.g., see Fig. 3.9c–e, p. 59), which requires more space and recording flexibility than the record form allows. The number of changes made en route to a correct design is a function of both item difficulty and the introduction of new types of patterns (e.g., diagonal lines) (Joy et al., 2001).

The kinds of strategies used to solve Block Design have been the subject of a running discussion in the literature for decades (Joy et al., 2001; E. Kaplan, Fein, et al., 1991; Spelberg, 1987). There seems to be little question that most normal subjects adopt an analytic approach. Kiernan and his colleagues (1984) point out, however, that the subjects of many of these studies have been bright adults: young children, some neurologically impaired patients, and some older subjects fall back on synthetic strategies because "they have difficulty doing the mental segmenting required by designs in which some of the edge cues are not present" (Kiernan, Bower, and Schorr, 1984, p. 706).

Test characteristics. The upward drift in test scores that occurs over time (the "Flynn effect", see p. 21), appears in Block Design scores too. According to the WAIS-III manual (Wechsler, 1997a), there was a 0.7-point differential between mean WAIS-III Block Design scaled scores (10.7) and mean WAIS-R scaled scores (11.4), based on the performance of 192 subjects who took the WAIS-R and the WAIS-III in counterbalanced order.

Age has a prominent effect on Block Design performance. One need only review the normative data through the presented age ranges to appreciate how much advancing age reduces performance levels on this test (e.g., J.J. Ryan, Sattler, and Lopez, 2000; D. Wechsler, 1955, 1981, 1997a). As was observed on WAIS-R Block Design (Heaton, Grant, and Matthews, 1986; A.S. Kaufman, Reynolds, and McLean, 1989), WAIS-III Block Design performance starts to decline as early as the mid-40s and continues to worsen with each decade (J.J. Ryan, Satler, and Lopez, 2000). Much of the difference between younger and older subjects lies in the speed with which designs are completed (Ogden, 1990; Salthouse, Fristoe, and Rhee, 1996). Among older subjects, reduced speed and accuracy are evident in the performance of the "old-old" (those over 80) when compared with the "young-old" (those in their 60s and 70s) (Howieson, Holm, et al., 1993; Joy et al., 2001). Education does not appear to contribute significantly to the decremental aging pattern (A.S. Kaufman and Lichtenberger, 1999; Salthouse, Fristoe, and Rhee, 1996). Block Design performance predicted the daily functioning of elderly (age 65–87), independently living persons as it correlated significantly with ratings on behavioral competency and several measures of the effectiveness of verbal communication (North and Ulatowska, 1981).

Men generally tend to score higher than women on Block Design, at least at younger ages (W.G. Snow and Weinstock, 1990). There is an almost one-point differential between the sexes for WAIS-R standardization population age groups within the 16– to 54 year range; from age 55 on, this difference shrinks to less than one-third of a point (A.S. Kaufman, Kaufman-Packer, et al., 1991) and is reported to be nonexistent for persons in the 65–74 and 80–100 ranges (Howieson, Holm, et al., 1993). This may in part be explained by hormonal factors. Testosterone supplementation—which also elevates estradiol levels—is associated with improved Block Design performance in older men (aged 50–80), whose baseline testosterone levels were in the low normal range for their age (Cherrier et al., 2001), but testosterone supplementation impaired performance in younger men whose baseline testosterone levels were normal (O'Connor et al., 2001). It has also been reported that younger women with higher estradiol levels do better on Block Design (Janowsky, Chavez, et al., 1998).

An approximately one-point difference in performances by whites and by African-Americans favors whites at all age levels (A.S. Kaufman, McLean, and Reynolds, 1991; Marcopulos, McLain, and Giuliano, 1997). However, deficient performances that appear at first to be attributable to race are in fact linked to disparities in education and acculturation (Ardila and Moreno, 2001; Manly, Miller, et al., 1998).

The internal consistency of the WAIS-III Block Design test is comparable to that of its WAIS-R predecessor. The manual reports split-half reliability coefficients for 13 age groups: these coefficients range from .85 to .90 in examinees under age 75, with slightly lower reliabilities (.76 to .81) observed in older examinees (Wechsler, 1997a). Slightly higher reliability coefficients (.88 to .95) were evident in most of the clinical samples, except for subjects with learning disabilities (.81) or hearing impairments (.77) (Zhu et al., 2001).

Test–retest reliabilities of the WAIS-III Block Design in 394 subjects retested over intervals of 2 to 12 weeks (with a mean of 34.6 days) ranged from .80 to .88 (corrected), depending on the age group. Similar test–retest reliability coefficients were observed in samples of adults with substance abuse disorders (J.J. Ryan, Arb, Paul, and Kreiner, 2000) and with complex partial seizures (R. Martin, Sawrie, et al., 2002).

Factor analytic studies of the WIS battery invariably demonstrate high loadings for Block Design on a Perceptual Organization factor, regardless of the number of factors derived or neuropsychological status of the subjects (J. Cohen, 1957a,b; Dickinson et al., 2002; A.S. Kaufman and Lichtenberger, 1999; J.J. Ryan and Paolo, 2001; van der Heijden and Donders, 2003; D. Wechsler, 1997c). Loading of Block Design on a Perceptual Organization factor holds across all age groups up to about age 75, at which time Block Design and other timed tests load more strongly on a Processing Speed factor. The WAIS-III manual confirms that Block Design performance correlates .48 to .52 with the predominantly verbal tests in the WAIS-III—Information, Vocabulary and Similarities.

Neuropsychological findings. Block Design is generally recognized as the best measure of visuospatial organization in the Wechsler scales. Block Design scores tend to be lower in the presence of any kind of brain impairment, suggesting that test performance is affected by multiple factors. In normal subjects, Block Design performance has been associated with increased glucose metabolism in the "posteroparietal region," particularly involving the right side (Chase et al., 1984). Studies of clinical populations corroborate the association of Block Design performance with right hemisphere, particularly parietal, function. In patients with lateralized lesions, Block Design performance is most often deficient when lesions are on the right side and involve posterior areas, particularly the parietal region (Newcombe, 1969; Warrington, James, and Maciejewski, 1986; Wilde et al., 2000), and is impaired less often when the lesion is confined to the left hemisphere—except when the left parietal lobe is involved (Benton, 1967; McFie, 1975). In Alzheimer patients, Block Design performance is strongly associated with atrophy in the right parietal region, specifically the size of the right anterior calcarine sulcus (Mega et al., 1998).

Patients with extensive right hemisphere damage that includes the parietal lobe or severe damage to prefrontal cortex and patients with considerable loss of cortical neurons as in Alzheimer's disease are all likely to perform very poorly on this test, but in different ways (e.g., Luria, 1973b). Defective Block Design performance by patients with lesions in either hemisphere or by a "split brain" patient can use only one hemisphere, convincingly demonstrate that both hemispheres contribute to the realization of the design: "neither hemisphere alone is competent in this task" (Geschwind, 1979). The nature of the impairment tends to differ according to the side of the lesion, however (Consoli, 1979). Patients with lateralized lesions tend to make more errors on the side of the design contralateral to their lesion. Edith Kaplan has called attention to the importance of noting whether lateralized errors tend to occur more at the top or at the bottom of the constructions, as the upper visual fields have temporal lobe components while the lower fields have parietal components. Thus, a pattern of errors clustering at the top or bottom corner can also give some indication of lesion site.

Patients with left—particularly left parietal—lesions often show confusion, simplification, and concrete handling of the design. Still their approach is apt to be orderly, they typically work from left to right as do intact subjects (i.e., intact subjects whose native language is read from left to right), and their constructions usually preserve the overall configurations (square shape) of the design. When they make errors, these will involve details of the design. They may be hesitant, and their greatest difficulty may be in placing the last block (which most often will be on their right) (McFie, 1975). Time constraints contribute more to lowering scores of patients with left hemisphere involvement than of those with right-sided lesions: when allowed additional time to complete each item, many patients with left hemisphere lesions will achieve scores within or even above the *average* range (Akshoomoff et al., 1989).

In contrast, patients with right-sided lesions will often work from right to left, may have difficulty with design orientation, and may distort major elements of the design. Some patients with severe visuospatial deficits will lose sight of the overall configuration of the block pattern altogether (see Chapter 3, Fig. 3.9c–e). Left visuospatial inattention may compound these design-copying problems, resulting in two- or three-block solutions to the four-block designs, with the whole left half or one left quadrant missing. Broken configurations are a common characteristic of the constructions of patients with right-sided lesions (E. Kaplan, Fein, et al., 1991). Broken configuration errors have been observed more often in epilepsy patients whose hemisphere focus is on the right than on the left (Zipf-Williams et al., 2000), and in patients with nonpenetrating head injuries who underwent right, as opposed to left, craniotomies (Wilde et al., 2000). Patients with right hemisphere strokes typically show a small but measurable improvement in their Block Design performance during the months following their stroke, whereas patients with left hemisphere strokes may or may not improve, presumably due to differences in the reasons for their initial poor performance (T. Sunderland, Tinson, and Bradley, 1994).

Patients with severe damage to the frontal lobes may display a kind of "stickiness" (see p. 82) on this test, despite assertions that they understand the instructions. With less severe frontal involvement, patients may fail items because of impulsivity and carelessness. Unable to conduct a thorough and logical analysis of the designs, they adopt a seemingly random approach to solving the problem and fail to appreciate or correct their errors (Johanson et al., 1986). Concrete thinking often shows up on the first item, for such patients will try to make the sides as well as the top of their construction match that of the model; some will even go so far as to lift the model to make sure they have matched the underside as well. Some of these patients may be able to copy many of the designs quickly and accurately, but they tend to fail design 11 (design 7 of the WAIS-R) by laying out red and white stripes with whole blocks, rather than shifting their conceptualization of the design from the mostly squared format of the first 3×3 design to a solution based on diagonals.

Block Design performance is relatively spared in patients with mild to moderate TBI, whose processing speed deficits are much more striking (Axelrod, Fichtenberg, et al., 2001; Correll et al., 1993). Acute TBI patients with CT evidence of frontal contusions are an exception and often do poorly on this test (Wallesch, Curio, et al., 2001), as do patients with moderate to severe TBI who subsequently undergo right craniotomies (Wilde et al., 2000). There is certainly variability in the extent to which TBI patients improve over the long term, but Block Design performance often improves (Millis, Rosenthal, et al., 2001). On average, even patients with severe TBI performed Block Design similarly to controls one year after their injury (H.S. Levin, Gary, et al., 1990).

In contrast, the Block Design scores of Alzheimer patients are typically among the lowest if not the lowest in the Wechsler battery (Fuld, 1984; Larrabee, Largen, and Levin, 1985; Storandt, Botwinick, and Danziger, 1986). It has also proven to be a useful predictor of the disease as a relatively low Block Design score in the early stages, when the diagnosis is very much in question, frequently heralds the onset of the disease (Arnaiz et al., 2001; L. Berg, Danziger, et al., 1984; La Rue and Jarvik, 1987), and thus aids in the critical differential diagnosis. It is also one of the most useful neuropsychological tests for predicting which patients will deteriorate the most rapidly (B.J. Small, Viitanen, et al., 1997) and for staging dementia progression (Herlitz, Hill, et al., 1995).

Alzheimer patients will, in the very early stages of the disease, understand the task and may be able to copy several of the designs. However, with disease progression, these patients get so confused between one block and another or between their constructions and the examiner's model that they may even be unable to imitate the placement of just one or two blocks. The quality of "stickiness," often used to describe the performance of impaired patients but hard to define, here takes on concrete meaning when patients place their blocks on the design cards or adjacent to the examiner's model and appear unable to respond in any other way. Alzheimer patients and those frontal lobe patients who cannot make the blocks do what they want them to do can be properly described as having constructional apraxia. The discontinuity between intent—typically based on accurate perceptions—and action reflects the breakdown in the program of an activity that is central to the concept of apraxia.

Patients with neurodegenerative diseases that typically involve subcortical structures—such as Huntington's disease, Parkinson's disease, and multiple sclerosis—often do poorly on Block Design, although less so than patients with Alzheimer's disease (Heaton, Nelson, et al., 1985; C. Randolph, Mohr, and Chase, 1993). Processing speed deficiencies and motor problems undoubtedly contribute to the performance impairments of these patients. Chronic alcoholics also perform poorly on Block Design, even after several months of abstinence (E.V. Sullivan, Rosenbloom, and Pfefferbaum, 2000; E.V. Sullivan, Fama, et al., 2002). Unlike patients with right hemisphere damage, alcoholics benefit more from not being timed and they typically do not break the design configuration (Akshoomoff et al., 1989). Block Design is also exquisitely sensitive to the subtle neurotoxic effects of exposure to lead (A. Barth, Schaffer, Osterode, et al., 2002; Meyer-Baron and Seeber, 2000) and to other heavy metals (A. Barth, Schaffer, Konnaris, et al., 2002).

Slowness in learning new response sets may develop with a number of conditions such as aging, a dementing process, frontal lobe disease, or head injury. The Block Design format is sufficiently unfamiliar that patients capable of performing well may do poorly at first if they have this problem. Since Designs 5 to 8 are quite easy for persons with *average* or better constructional ability, they give the patient who is slow to learn a new set the opportunity to gain needed familiarity. These patients tend to display an interesting response pattern in which the first two items are failed—or at best passed only on the second trial—while the succeeding two or three or more items are passed, each more rapidly than the last. Those patients who are slow in learning a response set but whose ability to make constructions is good may succeed on most or even all the difficult items despite their early failure.

Kohs Block Design test (Kohs, 1919)

This is the original block design test, differing from the WIS Block Design in that each block has four colors—red, white, blue, and yellow—each of which appears on one face of the block, while the other two faces each have two colors, divided along the diagonal. The 17 designs are different, too, many of them being more complex than the Wechsler designs. The administration and qualitative interpretation of the test results are essentially the same as Wechsler's. The almost universal use of the Wechsler scales in North America has made the administration of the Kohs Blocks redundant in most cases, although it is still used occasionally in other parts of the world. Pontius (1997), in a fascinating series of studies, has used the Kohs Block Design Test to illustrate that certain types of constructional errors—those involving subtle intrapattern visual details—vary from culture to culture as a function of the extent to which a culture is urbanized and literate. Kohs' test has some more difficult designs than Wechsler's. It has recently been adapted for use with visually impaired individuals (Reid, 2002).

Stick construction

Stick construction is a two-dimensional task in which the examinee puts sticks together in patterns. In its usual format as a copying task, the subject is required to reproduce stick patterns arranged by the examiner (K.H. Goldstein and Scheerer, 1953). Examinees can also be asked to construct their own designs with the sticks, to copy a drawing, or to compose simple geometric figures or letters (Hécaen and Assal, 1970).

Alfano and Michel (1994) hypothesized that using a two-dimensional drawing (either realistic or schematic) as a model requires the examinee to make an extra step—first processing the drawing as an object and then processing it as a symbolic representation of the stick array. Consequently, they found that healthy young adults made more errors when working from drawings as opposed to stick models. These subjects also took more time and made more errors when the stick patterns involved diagonally placed sticks as opposed to horizontal and vertical, implicating additional processing demands for diagonally oriented stimuli.

Matute and her colleagues (2000), using a stick test consisting of four increasingly complex constructions, observed that subjects' literacy level had a significant impact on both their overall performance as well as types of errors, as illiterate subjects made more disarticulation errors (inaccurately joined sticks) and reproduced fewer correct stick patterns than either literate or semiliterate subjects. Accuracy on the most complex stick pattern (an 11-stick house depicted in perspective) discriminated the performance of all three groups, with nearly all (96%) of the literates reproducing it correctly, compared with 76% of the semi-literates and only 52% of the illiterates. This study highlights the importance of considering an examinee's literacy level in interpreting performance even on ostensibly nonverbal tasks.

Twice as many right as left hemisphere impaired patients showed a severe deficit on stick construction tasks (14% vs. 7%) (Benton, 1967 [1985]). Approximately 20% of patients with lateralized lesions have some difficulty on this task regardless of the side of lesion. When attempting to construct a cube pattern with the sticks: patients with left hemisphere lesions copied stick models best, whereas right hemisphere patients copied drawings best (Hécaen and Assal, 1970).

Stick Test (Benson and Barton, 1970; N. Butters and Barton, 1970)

One version of the stick construction task includes a rotation condition as well as a standard copy condition. This ten-item test begins as a copying task. The examiner remains seated beside the patient throughout the first "match condition" part of the test. The examiner gives the patient four wooden sticks (approximately 5 inches long and 1/4 -inch wide with a 1/2-inch blackened tip) and then makes a practice pattern with two other sticks, instructing the patient to copy this pattern exactly. The examiner does not proceed until convinced that the patient understands and can perform this two-stick problem. The examiner then gives the test by constructing each design in numbered order (see Fig. 14.10, p. 563), requesting the patient to make a copy directly under that of the examiner.

On completing the ten copy items, the examiner moves to the other side of the examining table to sit opposite the patient. After constructing the same two-stick practice pattern made originally, the examiner now asks the patient to "make your pattern look to you like mine looks to me." If the patient does not understand, the examiner demonstrates the right–left and up–down reversals with the practice pattern. Once again, when the examiner is confident that the patient understands what is required, the items of the test are given in the same order as the first time. Patients are encouraged to take as much time as they feel they need to be accurate. Each condition is scored for the number of failed items. On the reversal condition, the test is discontinued after five consecutive failures.

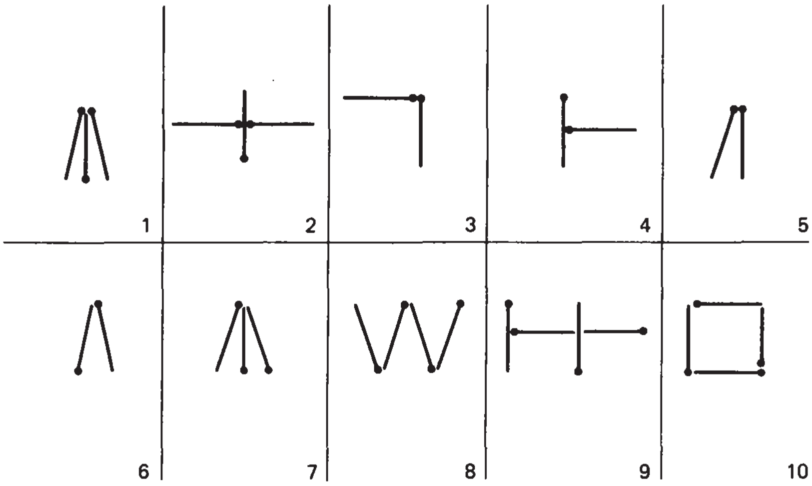


FIGURE 14.10 The 10 stick designs employed in the match and rotation conditions. (Butters and Barton, 1970. © Pergamon Press. Reprinted with permission.)

The findings on the copy task implicate postcentral lesions, particularly those localized in the right hemisphere. However, on the rotation condition, there was a significant ($p < .05$) tendency for patients with left postcentral lesions to make more errors ($M = 2.74$) than any other group. Those with right anterior lesions made the second greatest number of errors ($M = 2.13$), and the left anterior group made almost as few ($M = 1.69$) as did the 16 control subjects ($M = 1.59$) (Benson and Barton, 1970). The need for verbal mediation to handle the rotation task successfully was suggested as one possible reason for the relatively poor performance of the left posterior patients.

Object Assembly (Wechsler, 1955, 1981, 1997a)

One of the standard Performance Scale tests in previous versions of the WIS-A, Object Assembly was substantially revised and made an optional test on the WAIS-III. This test contains cut-up cardboard figures of familiar objects (see Fig. 14.11), given in order of increasing difficulty. The Mannequin (now called the Man), Profile, and Elephant have been retained from earlier versions, but the Hand item from the WAIS-R (which was similar in difficulty to the Elephant) was dropped, and two more difficult items—House and Butterfly—were added. The puzzle pieces now have numbers on the back to assist the examiner in laying them out as specified in the manual. All items are administered to every subject. Each item has a time limit (2 min for the two easiest puzzles, three min for the others), but unlike Block Design, partially complete responses receive credit too. Responses are scored for both accuracy and speed, with nearly one-third of the test's points (16 out of 52 possible points on the WAIS-III, 12 out of 41 on the WAIS-R) being awarded for speed.

Test characteristics. As in other speed-dependent tasks, performance levels on Object Assembly drop with age (Ivnik, Malec, Smith, et al., 1992b; A.S. Kaufman and Lichtenberger, 1999; J.J. Ryan, sattler, and Lopez, 2000). At ages 20–24, it takes a raw score of 34 to achieve the mean age-graded scaled score of 10, but only 26 points are needed at age 55–64 and only 18 points at age 80 and above (Wechsler, 1955, 1981, 1997). As an optional test that is no longer figures into the IQ scores and indexes, WAIS-III Object Assembly is often not administered in studies of the influence of demographic or clinical factors. WAIS-R studies of Object Assembly suggested that although there were no

FIGURE 14.11 WIS-type Object Assembly test item.

overall sex differences, men outperformed women in some age groups and women outperformed men in others (A.S. Kaufman, Kaufman-Packer, et al., 1991; A.S. Kaufman, McLean, and Reynolds, 1988). Education accounted for no more than 10% of the variance in WAIS-R Object Assembly scores (for the 35–54 age range) and as little as 2% (for 16-19-year-olds) (A.S. Kaufman, McLean, and Reynolds, 1988). African-Americans' average scores ran about two points below those obtained by white subjects.

It is not surprising that split-half reliability coefficients for Object Assembly reported in the 1997 WAIS-III manual are the lowest among the Wechsler tests (in the .70 to .77 for subjects under age 70, and from .50 to .68 in those over 70), as items differ markedly in number of possible points that can be earned (8, 12, 11, 10, 11) and in difficulty level. Internal consistency is higher among most clinical samples, with the exception of young adults with attention deficit disorder (.58) or learning disabilities (.51) (Zhu et al., 2001). According to the manual, test–retest correlations (corrected) on Object Assembly range from .74 in 16- to 29-year-old subjects to .82 in subjects ages 55–74, with coefficients for the oldest subjects being slightly lower (.76).

Of all the WIS-A tests, Object Assembly has the lowest association with general mental ability and, in healthy individuals, performance level tends to vary relatively independently of other WIS test scores (Wechsler, 1955, 1981, 1997a). It is most strongly correlated with Block Design (.61), no doubt due to their similarity in requiring subjects to synthesize a construction from discrete parts. Object Assembly requires little abstract thinking, but subjects do need to be able to form visual concepts in order to perform adequately on this test, and they must be able to do so quickly and translate these into rapid hand responses to earn *average* or better scores. Thus, Object Assembly is as much a test of speed of visual organization and motor response as it is of the capacity for visual organization itself (Schear and Sato, 1989). Visual acuity and dexterity also make significant contributions.

Neuropsychological findings. The speed component of Object Assembly renders it relatively vulnerable to brain impairment in general. As one of the more time-consuming WIS-A tests it is typically not included in dementia batteries. However, it has proven particularly sensitive to Huntington's disease, as it is often the most difficult test in the WIS-A battery for these patients (M.E. Strauss and Brandt, 1985, 1986) and shows the steepest score declines with disease progression (Brandt, Strauss, et al., 1984).

As a test of constructional ability, Object Assembly tends to be sensitive to posterior lesions, more so to those on the right than the left (F.W. Black and Strub, 1976). Thus, many patients, particularly those with right posterior lesions, who do poorly on Block Design are also likely to do poorly on Object Assembly. Differences in solution strategies tend to distinguish patients with left- or right-sided lesions (E. Kaplan, Fein, et al., 1991). The former are more prone to join pieces according to edge contours while ignoring internal features or relative sizes of the pieces, whereas the latter rely more on matching up surface details. To bring these differences out, Kaplan, Fein, and their colleagues developed two additional puzzles for the WAIS-R NI—a cow, which could best be solved by discriminating details, and a circle, which requires edges to be aligned for its solution. Patients with left hemisphere lesions would have more success with the circle; those with right-sided involvement would do better with the cow although, when the lesion involves the right posterior region, both puzzles would be likely to be failed.

Evaluating Block Design and Object Assembly together

The patterns of variations of Block Design and Object Assembly scores relative to one another and to other tests allow the examiner to infer the different functions that contribute to success on these tasks.

1. *Impaired ability for visuospatial manipulation.* The constructional rather than the perceptual component of this task is implicated when the patient performs better on such tests of visuoperceptual conceptualization and organization as the Hooper Visual Organization Test than on those requiring a constructed solution. This problem was described well by a 64-year-old logger who had had a right, predominantly temporoparietal stroke with transient mild left hemiparesis two years before taking the WAIS. When confronted with the Elephant puzzle he said, "I know what it's supposed to be but I can't do anything."

2. *Impaired ability for visuospatial conceptualization.* Other patients who appear unable to visualize or conceptualize what the Object Assembly constructions should be can put them together in piecemeal fashion by methodically matching lines and edges. Typically, they do not recognize what they are making until the puzzle is almost completely assembled. They are as capable of accepting grossly inaccurate constructions as correct solutions. They also tend to fail Block Design items that do not lend themselves to a verbalizable solution. Not surprisingly, these patients have difficulty with purely perceptual tasks such as the Hooper. Their

ability to conceptualize what they are doing does not seem to benefit from visuomotor stimulation, although their visuomotor coordination and control may be excellent. Their damage almost invariably involves the right posterior cortex.

3. *Ability for visuospatial conceptualization dependent on visuomotor activity.* Yet another group of patients, who typically have at least some right parietal damage, perform constructional tasks such as Object Assembly and Block Design by using trial and error to manipulate their way to acceptable solutions without having to rely solely on discrete features or verbal guidance. These patients seem unable to form visuospatial concepts before seeing the actual objects, but their perceptions are sufficiently accurate and their self-correcting abilities sufficiently intact that as they manipulate the pieces they can identify correct relationships and thus use their evolving visual concepts to guide them. They too do extremely poorly on perceptual tasks such as the Hooper, on which they cannot manipulate the pieces in order to develop a visual concept.

4. *Impaired ability to appreciate details.* Patients with left hemisphere lesions who do poorly on Object Assembly usually get low scores on Block Design as well. These patients tend to rely on the overall contours of the puzzle pieces but disregard such details as internal features or the relative size of pieces.

5. *Structure dependency.* Some patients may perform satisfactorily when a framework or pattern is available—as on Block Design or Matrix Reasoning as they can follow or pick out a ready-made pattern. They tend to have much more trouble with Object Assembly, the Hooper, or drawing a bicycle since these latter tests require them to provide their own structure to conceptualize, or identify, the finished product in order to assemble it mentally or actually. These patients usually have at least some frontal lobe pathology.

6. *Concrete-mindedness.* Still other patients may perform relatively well on Object Assembly since it involves concrete, meaningful objects; they may even do all right with the first two block models on Block Design, but they have difficulty comprehending the abstract designs on the reduced-scale pictures and thus perform poorly on Block Design as a whole. Again, some frontal pathology is usually implicated in these cases.

Three-Dimensional Construction

Block construction

The simple block construction tasks described here will elicit three-dimensional visuoconstructive defects. The revision of the 1960 Stanford-Binet battery (Terman and Merrill, 1973) contains two simple block construction tasks: *Tower* at age level II is simply a four-block-high structure; *Bridge* at age level III consists of

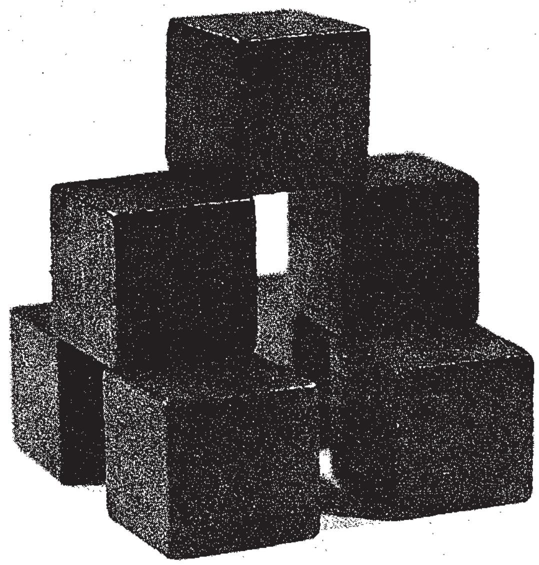


FIGURE 14.12 Block model used by Hécaen, Ajuriaguerra, and Massonnet (1951) to examine three-dimensional constructional ability.

three blocks, two forming a base with the third straddling them. The level at which age-graded tasks are failed provides a useful indicator of the severity of the impairment:

As points of reference, most three-year-olds can copy a four-block train (three blocks in a row with the fourth placed on one of the end blocks); most four-year-olds can build a six-block pyramid and a five-block gate composed of two two-block "towers," less than one inch apart, with each top block set a little back from the bottom block's edge, making room for a middle block to rest at a 45° angle. At five, most children can copy six-block steps but ten-block steps are too difficult for most six-year-olds. (E.M. Taylor, 1959)

Hécaen and his colleagues (1951) used seven blocks in their block construction task (see Fig. 14.12, p. 565). None of their six patients with severe visuoconstructive deficits associated with right parietal lesions was able to copy this construction correctly.

Test of Three-Dimensional Block Construction (Benton, Sivan, Hamsher et al., 1994)

Six block constructions are included in this test (originally called the *Test of Three-Dimensional Constructional Praxis*), three on each of two equivalent forms: a six-block pyramid, an eight-block four-level construction, and a 15-block four-level construction (see Fig. 14.13). The number of errors, namely (1) omissions, (2) additions, (3) substitutions, and (4) displacements (angular deviations greater than 45°, separations, and misplacements) that the examinee makes is subtracted from the total of 29 possible correct place-

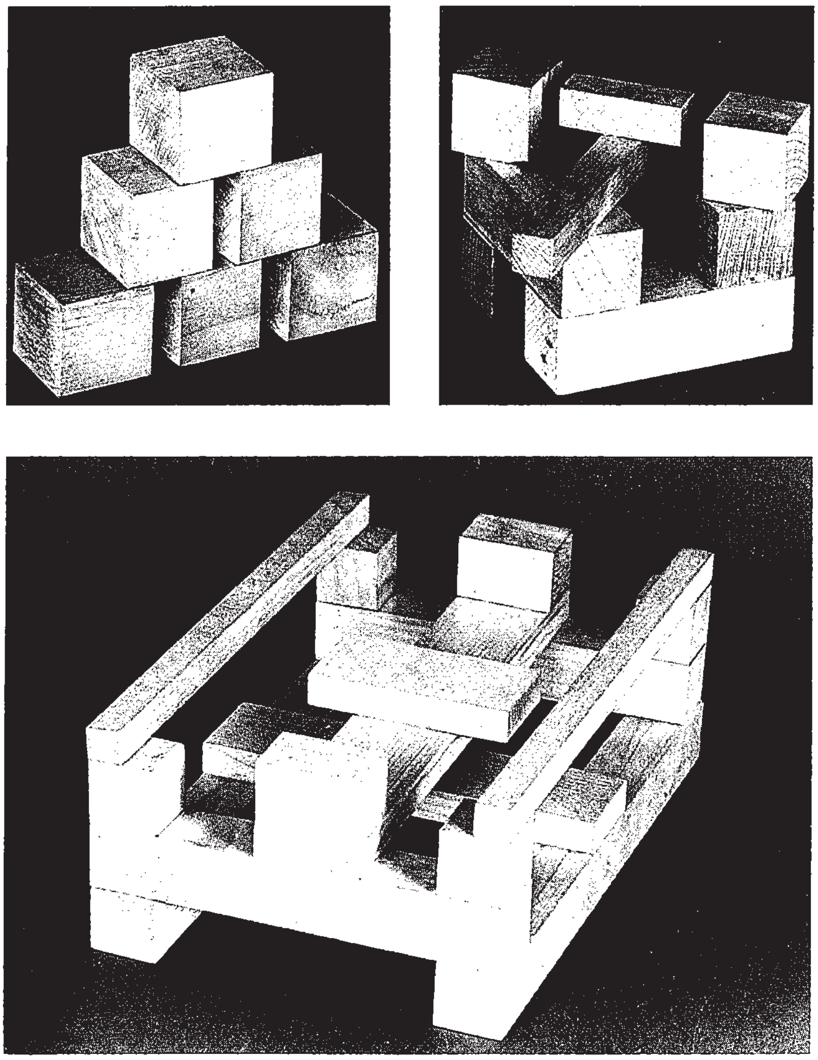


FIGURE 14.13 Test of Three-Dimensional Constructional Praxis, Form A (A.L. Benton). The three block models are presented successively to the subject.

ments. Rotations are not counted as errors, although these are noted qualitatively. The score should represent the fewest corrections needed to reproduce an accurate copy of the original construction. When the construction is so defective that it is impossible to count errors, the score is simply the number of correctly placed blocks. When the total time taken to complete all three constructions is over 380 sec, two points are subtracted from the total score. As on the Stick Test, both healthy and impaired subjects are more accurate when using a block model of the desired construction than when presented with a photograph (Benton, 1973).

Some of the construction problems exhibited by patients with impaired ability to build structures in three dimensions parallel those made on two-dimensional construction and drawing tasks. Thus, simplification (see Fig. 14.14*a*) and neglect of half the model are not uncommon (note also Fig. 14.14*b*). Failure on this task—defined as a performance level exceeded by 95% of the control group—occurred twice as frequently among patients with right hemisphere lesions (54%) as among those whose lesions were on the left (23%) (Benton, 1967 [1985]). A higher rate of defective performance on this task also distinguished right from left frontal lobe patients (Benton, 1968). Unlike other visuoconstructive tasks (e.g., block designs and stick construction), this test discriminates between groups of right and left hemisphere patients who are moderately impaired as well as between those who are severely im-

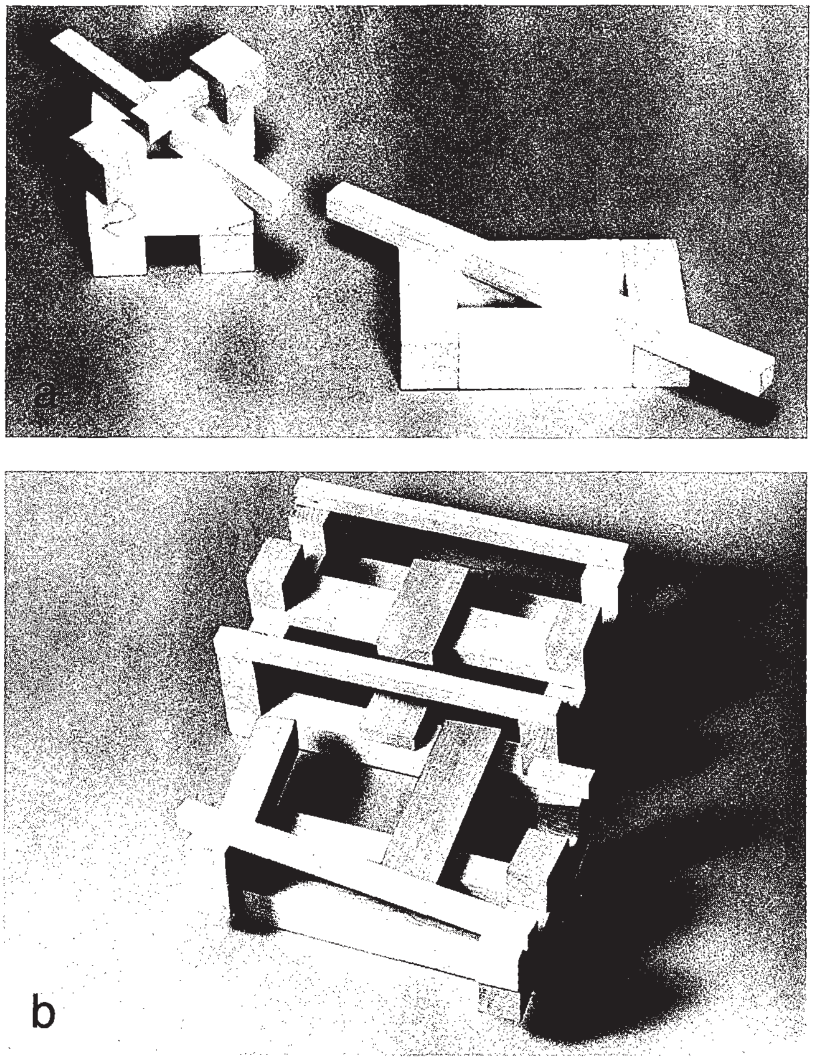


FIGURE 14.14 Illustrations of defective performances. (*a*) Simplified construction with inaccurate choice of blocks. (*b*) "Closing-in phenomenon" in which the patient incorporates part of the model into the construction.

paired (Benton, 1967 [1985]). One plausible interpretation of this finding is that the Test of Three-Dimensional Block Construction is more difficult and therefore better able to detect subtler visuoconstructive deficits that do not interfere with performance on less challenging tasks.

Miscellaneous three-dimensional construction tasks

In *Paper Folding: Triangle* at age level V of the revision of the 1960 Stanford-Binet (Terman and Merrill, 1973), the examinee is asked to copy a three-dimensional maneuver in which the examiner folds a square of paper along the diagonal into a triangle and folds that triangle in half. In Paper Cutting subtests at IX, XIII, and AA levels, the examiner cuts holes in folded paper so that the subject can see how the paper is cut but not how the unfolded paper looks. Subjects must then draw a picture of how they think the paper will look when unfolded. This test was included in a battery for studying the visual space perception of patients with lateralized lesions (McFie and Zangwill, 1960).

A different kind of spatial maneuver is required by Poppelreuter's test, in which the subject must cut out a four-pointed star following a demonstration by the examiner (Paterson and Zangwill, 1944). Patients with right parieto-occipital lesions were unable to perform this task. The possibility of using children's building toys (e.g., Lego type plastic blocks, erector sets, K'nex) for testing visuospatial functions should not be overlooked, even though—excepting Tinker Toys (pp. 621–626)—they have not been reported as standard assessment procedures.